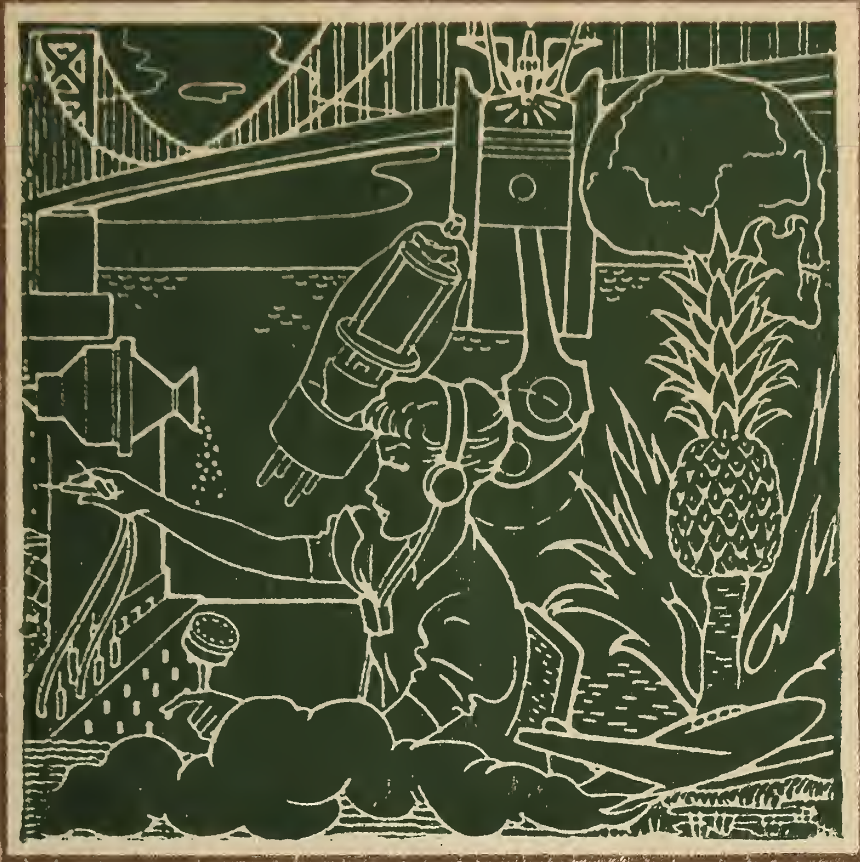

Teacher's Manual for

[...]W AND WHY CONCLUSIONS

The HOW AND WHY Science Books

Frosty, G. W.

A TEACHER'S MANUAL
AND SCIENCE HANDBOOK
to accompany

HOW AND WHY CONCLUSIONS
BOOK VIII

of the

HOW AND WHY SCIENCE SERIES

including also

A KEY TO THE COMPANION BOOK

Prepared by

DONALD G. DECKER

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THE HOW AND WHY SCIENCE BOOKS

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WINTER COMES AND GOES (GRADE 2)
THE SEASONS PASS (GRADE 3)
THE HOW AND WHY CLUB (GRADE 4)
HOW AND WHY EXPERIMENTS (GRADE 5)
HOW AND WHY DISCOVERIES (GRADE 6)
HOW AND WHY EXPLORATIONS (GRADE 7)
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HOW AND WHY CONCLUSIONS

A WORD TO THE TEACHER ABOUT THE TEACHER'S MANUAL

The good science teacher uses a variety of methods to teach his subject. He knows that many different learning activities are educationally sound. He also knows that there should be time provided for students to work individually so that he may give his attention to the study habits and the individual problems that students may have while they are working by themselves. The suggestions made in the teachers' manuals attempt to show many different ways to present information through a variety of activities so that individuals may apply their information in a number of different ways.

Suggestions are made to help the teacher develop with the students a method for constructing a study guide. When students are able to do this by themselves they will have acquired certain study habits and skills which will be of benefit to them later. It is suggested that a number of units be used in this way so that students accumulate the skills required to organize and follow through a study guide by themselves. There are also suggestions by which a teacher can develop certain scientific facts by a discussion of the diagrams and pictures in the units. If the school equipment is very meager the illustrations in the textbook and Companion Book may be used to great advantage. Some children who have difficulty with reading will appreciate the attention that is given to learning from diagrams and pictures. It is often well for the teacher and the students to work together in setting up problems and figuring out the information that should be used to solve them. Overview lessons may be presented by the teacher to discover the questions that students wish to have answered. The introductions to some of the units suggest that this method be used.

How well students understand science material may often be

discovered by work upon a program to be presented for the parents or material to be dramatized to illustrate to someone else what has been learned. The information presented in these programs must be accurate, and if students can repeat and apply accurate information in these kinds of situations they probably know the material very well.

Some suggestions are made for selecting facts from information to explain the pictures or to answer the topics and the problems in the unit. In using this manual, the teacher should think of it as a source of suggestions for the teaching of the material in the textbook and the Companion Book. If some of the methods are better suited to his purpose, those methods should be used and the pattern followed for other units suggested by the manual. If a teacher wishes to help students develop study guides and use this method for the study of each of the units, he should follow the same pattern suggested for the teaching of the first unit.

The suggested activities following the suggestions to the teacher are activities which pupils may enjoy in addition to the ones suggested in the textbook and the Companion Book. All of these methods, suggestions, and aids, are for the purpose of helping the teacher make meaningful the scientific facts of each unit. These scientific facts are listed for each one of the units. The manual is not intended to be a day-by-day direction to the teacher. After the teacher has read the textbook, the material in the Companion Book, and the material in the teacher's manual for any one unit, he should organize his own teaching procedures with these ideas in mind as suggestions. No printed material can do what the teacher can do for himself. Improvement must first take place in the mind of the teacher.

THE ORGANIZATION OF HOW AND WHY CONCLUSIONS

Two main objectives have been accomplished by the selection and organization of the units for How and Why Conclusions.

1. A presentation of the basic science subject matter important for children to experience while they are in school.

2. Examples of the application man has made of this subject matter to the solution of his problems and the improvement of his living.

The first part of each unit in How and Why Conclusions is organized to present the scientific information by experiences or examples which make it meaningful to the reader. The rest of each unit is devoted to describing applications man has made of this scientific information.

One of the objectives of educating public school children in the field of science is to make it possible for them to analyze, explain, or predict the events with which they come in contact, both in and out of school. Science education should serve a future purpose as well as an immediate one. Therefore, the applications which are explained should be those that are within areas that are constantly important to the welfare of man. There are many areas in science which are not of as great importance to the general public as are other areas. The topics listed in the table of contents show the major areas with which the children will deal. You and your ancestors, modern health practices, food preservation, the nervous system, bones, the heart and the blood are examples of areas of constant importance throughout life. The uses of metals, soil, plants and animals, and water are parts of the environment which continually change the things that we do as individuals throughout our life span. As long as man lives he will be concerned with communication, transportation, disease, and conservation. There may be other areas of equal importance, but one of the keynotes of the material presented in this book is that each of these units has been of continuing importance to classes of eighth-grade pupils. Classification of student questions constantly re-affirm the importance of these areas. The work of students in the elementary school, from kindergarten through the sixth grade, has been largely within these areas. How and Why Conclusions provides an opportunity to build upon the experiences of the seventh grade and the information and exercises in How and Why Explorations and its accompanying Companion Book. The material in How and Why Conclusions is not a repetition of the material in the previous book, but it further develops the same important areas

and adds new areas for study. This organization of material makes it possible to attain certain objectives that cannot otherwise be accomplished in a science program.

THE OBJECTIVES OF SCIENCE EDUCATION

Science teachers should always ask themselves: "For what purpose am I including this science subject matter as a part of the experiences of my students?" A good science teacher does not confine himself to teaching the material in the textbook. He provides experiences by which students can obtain objectives which they could not achieve if they dealt only with the textbook. For this reason the Companion Book should be used with How and Why Conclusions. Although the textbook and the Companion Book have been written to give the utmost assistance to the teacher by providing experiences which will accomplish certain otherwise unobtainable objectives, the skill of the teacher must still be used to make these meaningful to students. It is essential that the teacher have in his own mind the major outcomes for which he is educating his students. A student should have gained more than mere information as a result of his experiences in science. He should be able to use this information in a number of different ways. These are suggested below:

1. He uses the facts and principles of science which he has learned as tools with which to analyze the cause of events.
2. He uses the facts and principles of science as tools with which to predict the cause of events.
3. He uses the facts and principles of science with which to explain the cause of events.
4. He uses the facts and principles of science which he has learned as tools with which to analyze the result of events.
5. He uses the facts and principles of science as tools with which to predict the result of events.
6. He uses the facts and principles of science with which to explain the result of events.

A reference to the units included in How and Why Conclusions will help make these objectives more meaningful. As a result of his experience with the textbook and the Companion Book, a stu-

dent should be able to analyze the basic causes of changes in the body, metals in the earth, wounds, the operation of the telephone, food spoilage, the reactions individuals make to stimuli, disease, the operation of the radio, milk production, the functioning of the automobile, the heart, the blood, and the operation of airplanes. Of all the information which he gathers he should have developed the skill to select from that information the causes of certain things. This selection is dependent upon his skill to analyze in relation to the concept of cause. With this knowledge of cause he should be able to predict the results, and he should be able to analyze his information to discover the relationships which exist between the cause and the result. Each unit in the book emphasizes certain causes in relation to certain areas of science. Results of these are explained in the application of this information to problems which scientists are trying to solve.

If a student as a result of his science program does not know as much as those who have not had the benefits of the program, his education has been neglected. Students today have acquired a great reservoir of common knowledge from newspapers, magazines, the radio, movies, and travel. The units in How and Why Conclusions consist of information about which most people talk.

Teachers should feel a special responsibility to convince students that there has been a worthwhile effect on the welfare of man by solving problems with scientifically determined evidence.

Students should also be informed of the progress that man has made and the changes which have occurred as he has lived and applied scientific knowledge to the solution of his problems. The teacher who believes these objectives to be important will also be concerned in pointing out the relationships which exist between scientific knowledge and the social behavior of man. He will be sure to emphasize evidence which shows that the application of scientific knowledge has changed social institutions. Provisions must be made for students either to have their questions answered or to understand why the questions cannot be answered when they are asked. Students who have had a science program should desire to do those things that characterize a healthy and emotionally mature individual. They should also know other sources of scientific information so that they can continue to find answers to their questions when they are no longer in school. Basic to all of these

objectives is the emphasis which is given to the development of certain skills that are essential if a student is to continue his own learning.

It is true that these objectives emphasize social action and the results of man's application of scientific knowledge. In an age in which scientific information daily changes the lives of people, it is important that students first think of these social implications. If they should specialize in the field of science they will have developed a social consciousness in relation to the work which they are to do. Even though the student does not desire to make a career of science, his thinking and his attitudes toward the activities in which he does engage should be colored with science facts and a conviction that opinions, superstitions, prejudices, and unfounded beliefs are poor substitutes for the solutions of problems. American schools are designed to educate an American public whose members are going into many and varied life activities. Common goals, common interests, and objectives which are worthwhile to all are requisites of a science program in public education. Through such a program great emphasis can be given to the need for new scientists who will devote their energies, as scientists are now doing, to the improvement of the nation in which they live.

A SUGGESTED TIME SCHEDULE FOR TEACHING HOW AND WHY CONCLUSIONS AND ITS ACCOMPANYING COMPANION BOOK

Many teachers are interested in the amount of time that should be spent upon each unit. It is difficult to suggest a schedule which would be applicable to each school organization. The one presented in the chart below is constructed for a nine-months' course in which science is taught one hour a day each day of the week. Teachers should vary the time schedule to fit their own particular schools and classes. Some teachers plan to cover the entire book and other teachers plan to cover only a portion of it. The time schedule would have to be revised accordingly. It is important, however, that a teacher teach the units in the order in which they are written unless he has carefully organized the material to be sure that he is not asking students to study something for which they do not have the background.

Unit	Pages in Textbook	Pages in Companion Book	No. of Weeks (1 hr. per day)
1. The Human Body	5–15	1–12	1
2. Metals in the Earth	16–35	13–18	1
3. How Man Uses Metals	36–45	13–18	1
4. Modern Health Practices	46–58	19–25	1
5. A Call on the Telephone	59–78	26–31	2½
6. Food Preservation	79–87	32–34	1½
7. The Nervous System	88–105	35–42	2
8. Soil	106–130	43–61	2
9. Plants and Animals for Food	131–156	62–68	1
10. Scientists Combat Disease	157–172	69–77	1
11. Radio Broadcasting	173–190	78–81	2
12. Bones	191–200	82–85	1
13. The Milk Supply	201–210	86	1
14. Soil Conservation	211–242	87–98	2
15. The Automobile	243–274	99–110	3
16. The Earth Begins	275–319	111–124	3
17. Within that Shell	320–332	125–129	1
18. The Heart and the Blood	333–341	130–134	2
19. Our Water Supply	342–364	135–141	2½
20. Air Transportation	365–395	142–156	2½

MULTIPLE USES OF THE TEXTBOOK AND THE COMPANION BOOK

The charts which follow show the organization of the material in the textbook and the Companion Book according to a number of classifications.

Chart #1: (See pages 10 and 11)

1. The list of topics which compose How and Why Conclusions.
2. The pages on which scientific facts are taught in relation to each one of these topics.
3. The pages on which application in the textbook is made to the individual, the home, or the community.
4. The pages in the Companion Book of the exercises to use

to teach scientific facts in relation to these topics, in addition to the facts taught in the textbook.

5. The page numbers of exercises in the Companion Book in which the student must make application to the individual, the home, or the community.
6. In addition the chart also shows topics which are devoted to four major areas of importance in science education: conservation, health, transportation, and safety.

All of the material in the textbook and the Companion Book is so organized that a number of objectives of science education are accomplished at once. Unified learning is possible. The major areas of social concern are emphasized throughout both books. In addition to this unification of scientific fact and application, the Companion Book has been organized to develop certain skills. They are as follows:

Chart #2: (See pages 12 and 13)

1. Problem Solving
   a. The steps of problem solving
   b. The recognition of problems
   c. Stating problems
   d. Gathering and recording information
      (1) In charts
      (2) In diagrams
      (3) In drawings
      (4) In experiments
      (5) In graphs
      (6) In maps
      (7) In pictures
      (8) In tables
   e. Analysis
   f. Synthesis
2. Reading Skills
   a. Using an index
   b. Reading for specific information
   c. Reading to select main ideas in a paragraph
   d. Using reading signals

Application of skills and information learned in the Companion Book are also applied to the areas of conservation, health, transportation, and safety.

The charts indicate how many times throughout the year a stu-

dent will be working with the various skills and the various areas of subject matter and their application. If a teacher wishes to evaluate students on their ability to record information, a reference to Chart #2 indicates the ten exercises that could be used as a basis for this evaluation. If a teacher wishes to devise a marking scheme and to use a chart similar to the one printed, it would be possible at the end of the year to indicate the amount of growth that had occurred by reference to how well the student had done the exercises for any one skill. If a teacher wishes to review the area of health, Chart #1 indicates the pages and the units that should be reviewed in order to determine a student's comprehension of the important knowledge and attitudes in relation to this topic. If a teacher should wish to reorganize the material in the book, it would be possible to concentrate upon those problems which are of concern to individuals first. Since these have not been confined to one section of the book, the basic information needed for each unit will have been developed previously. The same organization could be followed for the home or the community. If a teacher or a school is attempting to unify social studies with science, as many schools are doing, Chart #1 presents the organization of the material in such a way that it is apparent which units can be used for various topics that are to be correlated with the social studies program. Other schools unify English and science. The development of the skills in reading are presented in Chart #2. When a student has finished the exercises in the Companion Book, he should be able to use his writing skills in making lists to classify things, construct sentences which state reasons, answer questions, describe, record facts, make lists of the order of a procedure, and construct sentences which explain why, how, or what happened. Little effort is required on the part of the teacher to do other than to emphasize the many things the student is learning at once. The facts he learns in science become useful tools to him in relation to four major areas, to four areas of social application, and to a variety of skills involved in problem solving and the recording of information in many forms. Reference to the charts will help the teacher introduce each unit and series of exercises in the Companion Book so that students will know the variety of things they will be doing as they study the textbook and do the exercises in the Companion Book.

CHART 1—HOW AND WHY CONCLUSIONS TEXTBOOK AND COMPANION BOOK

Units in How and Why Conclusions and Its Accompanying Companion Book	Sci. Fact		Application of Scientific Fact															
	T *	C †	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
	Scientific Fact	Scientific Fact	Individual	Individual	Home	Home	Community	Community	Nation	Nation	Conservation	Conservation	Health and Safety	Health and Safety	Communication	Communication	Transportation	Transportation
1. The Human Body	5–15	5, 7, 8, 9, 12	5–15	10–11, 12	13–15	10		5		1–4								
2. Metals in the Earth	16–22	14							16–35	15	16–35	15						
3. How Man Uses Metals	36–45				40–45		40–45		36–45	17	36–45							
4. Modern Health Practices	46–58		46–50	19, 20, 24, 25	51–58		20–21	22, 23 24					46–58	19–21 22–23				
5. A Call on the Telephone	59–68	26, 31			59–68	26	69–78								59–78	26, 27, 28, 29, 30		
6. Food Preservation	79–87				80–87	32, 34		32					79–87					
7. The Nervous System	88–105	35–41	88–105	35–41									88–105		88–105	35–41		
8. Soil	106–123	43 51–56	124–130				106 123	44–45 48	106–123	49 51–56	106–123	43–47 51–54						
9. Plants, Animals for Food	131–156	63 64					131–156	62 67–68	131–156	63, 64 67	131–156	64 65						
10. Scientists Combat Disease	157–172	69 70, 72		69, 70, 71			157–172	71 75	157–172				157–172	69, 70, 71				

* T = Textbook
† C = Companion Book

CHART 1—HOW AND WHY CONCLUSIONS TEXTBOOK AND COMPANION BOOK

Units in How and Why Conclusions and Its Accompanying Companion Book	Sci. Fact		Application of Scientific Fact															
	T *	C †	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
	Scientific Fact	Scientific Fact	Individual	Individual	Home	Home	Community	Community	Nation	Nation	Conservation	Conservation	Health and Safety	Health and Safety	Communication	Communication	Transportation	Transportation
11. Radio Broadcasting	173–185	78, 79, 81			173–185	78, 79	186–190	78, 79	186–190	78, 79					173–190	78, 79		
12. Bones	191–194		195–200	82, 83, 84									191–194	82, 83 84				
13. The Milk Supply	201–206	86				86	201–206						201–206	86				
14. Soil Conservation	211–242	95–97					211–242	90–93	211–242	87, 88 89, 94 95, 97	211–242	87, 88 89, 94 95–97						
15. The Automobile	243–274	99–109		110									243–274	99–110			243–274	99–110
16. Within that Shell	320–332	125			320–332	126	320–332						320–332					
17. The Heart and the Blood	333–341	130	333–341	133 134				130–132					333–341	130 133 134				
18. Our Water Supply	342–364	135			342–354 358–364	141	342 358	136 137 140	342–354		342–354		359–363					
19. Air Transportation	365–404	142 146 147						142 143	365–404	146 147 153–155			365–404				365–404	142–147 149–152

CHART 2—HOW AND WHY CONCLUSIONS COMPANION BOOK

Units in How and Why Conclusions	Problem Solving										Reading Skills		
			Gathering and Recording Information										
	Steps of Problem Solving	Recognizing Problems	Charts	Diagrams and Drawings	Experiments	Graphs	Maps	Pictures	Analyzing	Synthesizing	Use of Index	Selecting Specific Information	Using Reading Signals
1. The Human Body		1–4	10, 11	9		10–11			5–7 12	9	8		
2. Metals in the Earth					18		15			13		14	14
3. How Man Uses Metals			17	16								16	
4. Modern Health Practices					21, 22		20	20					
5. A Call on the Telephone				26, 29 27, 28	26, 27								
6. Food Preservation					32, 34			32		35			
7. The Nervous System								35–41	35–41	35–41			
8. Soil	46, 47				46–48 57–61		44–45 49–50	43	49 51–56			64 67, 68	
9. Plants, Animals for Food			64 66	62, 67, 68				65	63 66, 67, 68	65			
10. Scientists Combat Disease			72	70		69 73–74	76	71					
11. Radio Broadcasting				80	80, 81			78, 79					
12. Bones								82, 83 84					

CHART 2—HOW AND WHY CONCLUSIONS COMPANION BOOK

Units in How and Why Conclusions	Problem Solving										Reading Skill		
			Gathering and Recording Information										
	Steps of Problem Solving	Recognizing Problems	Charts	Diagrams and Drawings	Experiments	Graphs	Maps	Pictures	Analyzing	Synthesizing	Use of Index	Selecting Specific Information	Using Reading Signals
13. The Milk Supply			86		86				86				
14. Soil Conservation							95, 96 97	87, 88 89, 94	94				
15. The Automobile			110	99–109	103 104								
16. Within that Shell			126		126				125			127	
17. The Heart and the Blood			133 134	130	130–133								
18. Our Water Supply				140	135 138–141							136 137	
19. Air Transportation			149–152		142 145 148 150		143	145				144	

THE DEVELOPMENT OF SKILLS

PROBLEM SOLVING

The elements of problem solving should always grow out of experience. They are more meaningful if they are the result of experience rather than the experience itself. If children are taught lessons in which they learn the steps of problem solving and are expected to know these steps at the conclusion of the lesson, problem solving will never be as meaningful to them as when they engage in experiences in which they discover for themselves the value of the scientific method and the usefulness of the steps in problem solving. In addition to recognizing the steps of problem solving, it is important for students to be able to explain why problem solving is valuable and useful. The student who has come to the conclusion, through experience, that problem solving is valuable can use the method to direct, change, and transform future experiences.

The teaching of problem solving has probably been more consistently "butchered" by science teachers than the teaching of any other area in the field of science. Most teachers recognize the benefits of teaching problem solving but they fail in their endeavors to accomplish what they set out to do. There are several reasons why this is true. Often teachers believe that all the skills involved in problem solving must be taught at the same time and that each student will be equally proficient in these skills. Other teachers leave the teaching of problem solving to be absorbed by the students without direct effort to help them learn to be skillful in the use of this method. Students who have not developed skills in problem solving need to have the method taught to them as carefully as one teaches the subject matter in the textbook. The great objective of problem solving is to make students intellectually independent of others in the acquisition of information. Students remain intellectually immature as long as they are dependent upon others to direct their learning activities. The exercises in the Companion Book are designed to help in the gradual development

of these skills. If a teacher concentrates upon the development of one skill at a time, he will probably be more successful in teaching problem solving to his students. No teacher will succeed in teaching problem solving if he himself has not acquired the skills. The teacher also needs to recognize the various parts of problem solving in relation to each other.

Recognition of Problems

The first essential in problem solving is the recognition of a worthwhile problem. Students can be taught to recognize worthwhile problems if definite standards are developed which can be used to judge problems that are being evaluated.

1. A good problem contains only one main idea. Questions which contain two main ideas divide the attention of the learner and make it necessary for him to solve two problems at the same time which is somewhat difficult for him to do. There are a number of different ways to help children recognize the main idea of a problem. One is to list a number of problems which children suggest and then to ask the students to underline the main idea. For example: "How can light be used to take pictures?" The main idea in this problem is light. The rest of the problem concerns itself with a special application of light. Another exercise in using this standard to evaluate problems would be to list the problems and questions in How and Why Conclusions and then to underline the main idea in each of these problems. Another kind of exercise would be to list the topics in How and Why Conclusions and to ask the students to change these topics into problems and then underline the main ideas. These could be done at the beginning of the year as a survey of the contents of the book that the students are to study and to provide the teacher with information as to how well students can judge a problem by this one criterion.
2. A good problem usually begins with *how* or *why*. Problems which begin with these words demand a recognition of relationships in the evidence which is gathered to solve the problem. A conclusion which answers the question of how or

why demands a statement of relationships. Questions which can be answered with a list of things, a definition, or yes and no, are not the best kinds of problems because they do not demand so high a degree of learning.

3. A good problem is stated in question form. It should begin with a capital letter and end with a question mark.

4. A good problem emphasizes a social application of scientific information if possible. It is of importance to students. It is challenging to them. It can be answered. If students can recognize and state problems which conform to these standards, they have developed one skill essential to problem solving.

The statement of a good problem is not the end of education in problem solving, but identifying in that problem the purpose or the reason or the application is one of the significant objectives. "How can I make the problem most worthwhile to study?" should be the major concern of those who work on problems. When a problem has been stated well, it is comparatively easy to outline the things that need to be done in order to solve the problem. Usually the first activity is to list the sub-problems which must be answered before the main problem can be solved.

Making a Study Guide

When the sub-problems have been stated and it is recognized that these may be either simple questions or problems, a student is ready to decide the activities which will help to provide information to answer these questions and problems. The student may plan to read, to observe, to experiment, or to listen in order to gather his information. The amount and kind of reading that he does will depend upon materials available. Those things which he observes will be dependent upon the equipment in the school and the kind of community in which he lives. This will be true also of the experiments that he can do. Listening includes activities such as interviews, guest speakers, discussions, and committee work. These again are governed by the people available in the community, the school, and the amount of time that can be de-

voted to such activities. It is wise for the student to get into the habit of planning carefully and realistically the things he can do.

Gathering Information

The student should make a survey of the available materials, equipment, and people from which he may gather information about his problem. Several suggested activities in the teacher's manual will help teachers plan with students for the activities that it is possible for them to do to solve problems. Even though the activities are confined to the use of How and Why Conclusions and the accompanying Companion Book, and the simple material suggested for the demonstrations and experiments, the student can learn the basic skills of problem solving which will not change when more materials and greater opportunity is provided for gathering information from a wide variety of sources. A teacher does not need to feel hampered because the equipment is meager or the time not available for many different kinds of activities. The teacher should remember that the student is going to study by some method. It is no more time-consuming to study by the problem solving method than by any other. If movies, field trips, interviews, and library work are included, the method is not more time-consuming, but the activities which are used consume time. The basic essentials can be learned in the same amount of time that it would take to use any other method for study. At the beginning of problem solving the wise teacher does not permit the student to gather so much material that it is not possible for him to organize it. Teachers often make the error of urging a student to acquire a great mass of material which would take six months to organize. This is why it is so important that a teacher approve study outlines before students begin to work upon them. A few well chosen activities can result in more worthwhile information than a great list of exciting and varied activities may do. Students always want to do more things than they can possibly do in the time allowed. If teachers permit this to happen, both teacher and students finally come to the conclusion that there is not time to do it all, that the students have wasted their efforts, and that problem solving is a poor way to teach. Teachers should blame themselves for the inadequate directions which they have given students

rather than blaming the method, which is at the mercy of the teacher. Activities should always be planned in relation to the amount of time available for the solution of the problem. Any one of the units in How and Why Conclusions might consume a whole year if children are allowed to perform every activity which they suggest in connection with each unit. It is also the responsibility of the teacher to evaluate the suggestions that students make, and to make suggestions to the students of worthwhile activities. Teacher-pupil planning in problem solving should not result in a teacher's losing his function in the classroom. His effect upon the students should be more worthwhile. He should always be looked upon as the person whose experience and training make him capable of evaluating and determining the activities that should be performed.

Analyzing Information

When the information has been gathered it may be in the form of notes, charts, diagrams, maps, or pictures. As soon as the gathering of information is completed, the student should sit down with this information and write on a piece of paper the question or problem he wishes to answer. He should underline the key ideas in this problem. With these in mind he should review the information he has collected. Under the problem he should write in sentence form the information from his material which will help to answer the problem. When the student is listing his information in sentence form under each one of the problems, he is performing the activity called "Analysis of Information." It simply means that he is selecting from his information those ideas which are related to the main ideas in the problem he is solving. Eighth-grade students are able to understand this explanation of analysis. As they become more skillful in the use of the problem solving method they will be more critical of the information they gather. The teacher or the students should not be discouraged if useless information has been included. The only person who can learn to use the problem solving method is the learner. He will never achieve proficiency if all the thinking occurs in the mind of the teacher. A teacher must be content to allow students to learn by the experiences which they themselves have. Education is

more meaningful to those students who are allowed to make conclusions themselves on the basis of their experiences than is education where all the conclusions are made by the teacher. The thrill and the excitement of feeling the satisfaction of improvement cannot come if the teacher is the only one who improves. It is the responsibility of the teacher to urge students to evaluate their experiences so that they will consistently gather better information and make wiser selections as they gather it.

Synthesizing Information

The next step in problem solving has always been difficult for teacher and student to understand. This is usually true because the purpose has not been clear to either one. After the evidence has been listed in sentence form under each question or problem, a student may discover he has a list of twenty ideas, each one related to the problem. What is the next logical step to perform in getting an answer to this problem? The student needs to summarize this information into a conclusion which will answer the problem. Certain skills will help a student do this. For example: He may underline each word in the sentence which is related to a main idea in the problem. The next step is to group these words which he has underlined so that those that are related are grouped together. There are two things that the student does unconsciously when he is constructing these groups: (1) in order to put words together in one group he needs to recognize similarities among ideas; (2) in order to place words in different groups he must recognize differences among the ideas. The basis of this step of problem solving is concerned with the recognition of similarities and differences. The third part is a more difficult function of the learning processes—it is learning to recognize relationships among these groups of ideas. These relationships are identified by the main ideas in the problem. The student should always ask himself, "What is the relationship I am trying to explain? How are these ideas connected? Why does one idea help explain another?" When he has decided what this relationship is he is ready to state the conclusion to his problem. This process is called synthesis. Synthesis means that a person has identified and grouped the main ideas together. If a teacher directs students through the

process of synthesis according to the suggestions above and then says to them, "What is it that we have done?" students are able to list the steps which have been performed. If the teacher then says that these steps represent the process called "synthesis," the student identifies in his mind this word with activities he has already performed.

Making a Conclusion

When the conclusions have been stated for each one of the subproblems, it is again necessary to synthesize in order to make a statement which will be a conclusion to the main problem. The same procedure can be used again. When the student has his conclusion to the main problem, it is well to verify it by reviewing his evidence, doing additional reading, asking an authority, doing other experiments, or by comparing his conclusion with others made by students in the class. Many science teachers believe that the end of problem solving should be application of the conclusion to social situations in which it can be used to explain, predict, or analyze. The application of the information with which the student deals should be a part of each experience he has with his problem so that the significance of it is a constantly growing and expanding concept. Too often the information is gathered and the application of it inconsequential and hurried. A good summarizing activity in which conclusions can be used in the framework of application is to suggest many different situations to see if the student can recognize the similarity between the situation and the conclusion he has made. This is also an excellent way in which to evaluate the meaning the student has developed in relation to the conclusion he has made. Other teachers believe that a hypothesis should be included as a part of this procedure. In a question such as, "How can light be produced without heat?" it may be impossible for a student to make a hypothesis if he is entirely ignorant of the basic facts connected with the problem and if he has had no previous experience upon which to make a hypothesis. Forming an hypothesis and verifying are two steps in problem solving which often seem inconsequential to students because one has to "stretch his imagination" in order to perform either one of these steps. The essential scientific attitudes can be

developed without the inclusion of these two steps at the junior high school level. If the problem is one about which a person can make a sensible hypothesis and one in which verification is possible, then these two steps should be included. The teacher should always emphasize the fact that any conclusion to a problem is not recognized as the final one—that it is important only as it reflects the evidence which has been gathered. If more evidence is gathered and more time is devoted to it, the conclusion may change. For this reason most conclusions made by students in the eighth grade are in the nature of hypotheses. As students grow and develop in their proficiency they can perform more and more of these steps by themselves. A good foundation in problem solving in junior high school should make it possible for a student to direct efficiently a great deal of his own study in senior high school.

READING SKILLS

Most of the activities students perform in junior high school in relation to science are reading activities. If science is to be learned, reading skills must not be neglected. It is often true in the junior high school that the reading skills so carefully developed in the elementary school are either neglected or forgotten entirely. As reading materials change and increase in complexity, the skills the student has learned in elementary school should be re-applied to each new kind of material. Only through their application do students continue to be proficient in the use of them. Several reading skills most essential to the selection of important information from reading material are emphasized in the Companion Book. There are exercises which suggest to teachers ways of helping students do the following:

1. To identify the meaning of new words.
2. To recognize reading signals which indicate how many, results, definitions, and causes.
3. To select specific ideas to answer questions.
4. To recognize the main ideas in a paragraph.

Each one of the exercises which has been made to further these skills in reading can be used as suggestions for the teacher to de-

velop other exercises which can be made for other sections of the book. At the beginning of the year's work the teacher should identify the exercises in the Companion Book which are designed for this purpose (see Chart #2, pages 12 and 13) and make more of his own if he feels this is an important thing to do. Space in the Companion Book does not permit the inclusion of the number of exercises actually necessary to constantly and consistently develop these skills.

THE RECORDING OF INFORMATION

It is easier to judge the understanding which children have of information if they can record the same information accurately in a number of different ways. A student who can record his information in writing, in a bar graph, a circle graph, a line graph, a picture, a diagram, and a map probably understands and can use his information as a tool. For this reason many of the exercises in the Companion Book demand that students record their information in a variety of different ways. Certain exercises are devoted to the teaching of the skills essential for this. Other exercises help students to select information from a variety of different sources (see Chart #2, pages 12 and 13).

EVALUATION

Teachers who concentrate upon the improvement which students make can usually demand a higher type of achievement of their students than teachers who do not emphasize improvement as a major objective of the year's work. If students are evaluated upon the amount of improvement they make individually rather than in competition with other students, there is more incentive to improve. A student may feel that it is possible for him to improve but he may also know that it is impossible for him to improve to the same degree that another student in the class does. Therefore, individuals should be evaluated by the actual improvement that takes place. It is still necessary in some schools to evaluate students in relation to each other. Therefore, two types of evaluation should be made by the teacher. The former is more meaning-

ful to the students, the latter may be an administrative necessity. Most students like to know how well they do in relation to themselves and also in relation to other students in the class. The following criteria for evaluating students in the science class is suggested:

1. The student knows the scientific information in relation to each topic in the textbook and the Companion Book.
2. He can use scientific information to explain what happens in the human body.
3. He can use scientific information to predict what will happen in the human body.
4. He can use scientific information to explain events in his home.
5. He can use scientific information to explain events which occur in his community.
6. He uses the steps of problem solving.
7. He recognizes problems.
8. He states problems.
9. He analyzes information.
10. He synthesizes information.
11. He uses an index correctly.
12. He can obtain information from maps.
13. He can read for specific information.
14. He can select the main ideas in a paragraph.
15. He can select information from a table.
16. He uses reading signals.
17. He records information accurately in diagram form.
18. He records information accurately by drawing.
19. He records information accurately in graph form.
20. He records information accurately on maps.
21. He uses safety skills.
22. He uses experiments as a source of information.

A teacher may use the following symbols to record how well the student has achieved the above objectives: An "O" may be used to indicate outstanding achievement, an "S" for satisfactory achievement, an "N" if the student needs to improve, and a "U" if the student is unsatisfactory. If at the end of the year a student has

received "S" consistently in any one of the above objectives he will be rated as satisfactory. Students should know and perhaps keep their own records so that they can judge the progress they are making in the development of these skills for the learning of science subject matter and its application.

THE SCIENCE ROOM

PLANNING THE SCIENCE ROOM *

Ideally a science room should be planned as a place where students may carry on all the science activities that contribute to the objectives of science instruction. This means that a science room should be equipped for general classroom activities, demonstration work, and laboratory work. Such a room will make it possible for teachers and pupils to change quickly from one type of activity to another and thereby provide better co-ordination between all science activities. Such a plan will also eliminate the economic losses that are encountered when science laboratories are separated from the science classrooms.

Size of Science Rooms

There is at present no scientifically standardized size for a science room. Science rooms will obviously differ considerably in size, depending upon the number of pupils to be accommodated. For an efficient science program, in justice to both pupils and teacher, the laboratory class should not exceed twenty pupils. Where classroom work other than individual laboratory work by pupils is conducted, a room sufficiently large to accommodate thirty pupils may be used.

It is highly desirable, when a new school building is to be built, that the science staff, the school administrators, and the architect work together in planning the details of the science rooms.

Laboratory Furniture

A large, instructor's demonstration table (8 to 12 feet in length) should be centered in the front of the science room. This should be equipped with running water, a sink, and gas and electrical out-

* The sections entitled "Planning the Science Room," "The Planning and Purchase of Equipment," and "Homemade Equipment" on pages 25–34 are quoted directly from the *Forty-Sixth Yearbook, Part I, Science Education in American Schools,* pages 240–247, by permission of the National Society for the Study of Education, Mr. Nelson B. Henry, Secretary.

lets. It should have an acid-resistant top and drawer space for items needed in demonstrations. Properly designed cupboards should be provided for regular storage of materials and equipment.

Several different plans may be used to provide accommodations for laboratory work. One plan is to provide about thirty arm-table chairs in the front of the room facing the demonstration table. Back of the chairs are placed laboratory tables. Movable stools with rubber tips are provided if pupils sit down when doing experiments. Another plan is to equip the room with special-type laboratory tables, such as the Lincoln desk, which permit the pupils either to sit or stand when doing experiments or when they are participating in demonstration-recitation lessons.

Experience has shown that it is more economical to equip a science room with the very best materials. Laboratory furniture bought from reputable manufacturers is usually better than the homemade variety. The plumbing fixtures should be brass or copper, chromium plated, and made for long, hard service. Laboratory sinks should be made of or lined with soapstone. Plenty of drawer space should be available in the laboratory tables.

Cabinets and Chart Cases

A wide variety of objects, specimens, and models are used in teaching science. Cases and cabinets for display and storage of these materials are necessary in the science room. Storage and display cabinets should be equipped with rolling doors that move freely on steel tracks. Adjustable shelves are also helpful. An exhibition case for displaying completed student projects is an excellent motivating device in a science room. A notebook cabinet in which the pupils may place their records of completed projects and experiments is also useful.

Since both homemade and commercial wall charts are being widely used to give a clearer meaning to the ideas of science, a chart case or a rack with rollers is very desirable.

Provisions for Use of Visual Aids

Motion-picture, slide, opaque, and micro-projectors are used in teaching science. Special care must be taken with the windows

so that the science room may be easily and quickly darkened. Boxed-in opaque window shades are generally considered best for this purpose. Proper screens, both "daylight" and reflecting, are required equipment. Electrical outlets must be conveniently placed in the room.

Bulletin Board and Blackboard

Every science room needs a large permanent bulletin board. Its uses are many. Photographs, diagrams, and clippings may be posted on it. It may be used as a place to exhibit exceptional work done by pupils. It is an excellent place to post assignments and notices.

A bulletin board may be made by tacking a piece of plain green denim over smooth pine or a piece of Celotex. Bulletin boards may also be made from Compo-board. A frame around the board will make it more attractive.

Blackboards should be provided along the front and at least a part of one side of the science room.

Aquariums, Terrariums, and Receptacles for Growing Plants

The stockroom should be large enough to provide adequate space for storage. It should also provide enough room for the preparation of solutions and demonstration setups. Cases or cupboards containing a large number of drawers and shelves that will provide a space for everything are necessary. A sink with running water should also be provided.

A darkroom should be planned as an adjunct to the science classroom. It is important for experiments in optics and photography in physics and chemistry. It may also be used for certain experiments in general science and biology, such as those dealing with plant growth and tropisms.

THE PLANNING AND PURCHASE OF EQUIPMENT

The planning and purchase of equipment for demonstration and laboratory work is an important function of the science teacher. Since funds are frequently limited, it is important that these funds

be spent wisely and in many cases that inexpensive substitutes be provided for more expensive apparatus. The following suggestions are offered as a guide for systematic planning and purchasing of science materials.

Determine the Kinds of Equipment That Are Most Needed

Preliminary to the proper selection of equipment, it is necessary, first of all, to ascertain in complete detail the outline of the course of study to be followed in a particular science subject. Once this has been done the types of materials most desirable may be listed under the following heads:

1. Needs for demonstration work
2. Needs for laboratory work
3. General laboratory equipment, such as tools, electrical, water, and gas supply.

Plans for Purchasing Equipment

The science teacher needs an annual budget. It is a legitimate function of the science teacher to show the school administrator that a certain annual expenditure is necessary for efficient science teaching and learning. Depending upon the present condition of the laboratory-classroom, it may be advisable to plan two budgets: one budget made up of annual supplies, such as breakable glassware, chemicals, dissecting materials, and other needed yearly replacements, and another budget consisting of items, listed in order of preference, based upon a long-term plan for building up the science equipment.

It is not advisable to depend solely upon scientific supply houses for science materials. Mail-order houses, dime stores, junk yards, auto graveyards, and local industries are excellent potential sources of physical-science equipment. To make science teaching more life-like, "real" articles such as a real lift pump, an auto jack, or a discarded automobile engine should be purchased in preference to models. In the biological field much interest may be aroused and firsthand information acquired when students have to collect the insects, earthworms, leaves, flowers, and stems which they are to dissect and study.

It Is Desirable to Have a System for Storing Equipment and to Keep Accurate Records of All Science Materials

Science materials should be card-catalogued. A card for each type of equipment should contain the date of purchase, the number of units, the condition of the equipment, and the date when repairs are made. Cases, bins, drawers, and cabinets should be labeled. This system will assist in preventing apparatus and materials from being misplaced or lost.

HOMEMADE EQUIPMENT

Need for Homemade Equipment

Experience in science need not be lacking because of the absence of commercial supplies and equipment. In fact, for a program where one desires to stress pupil activity with application of science principles to everyday living, the use of improvised equipment and devices from the home, garage, and farm may prove more functional than an abundance of purchased apparatus. Pupil experiences in making the needed apparatus for a demonstration or project, by using tin cans, scrap wood, wire, and glass, with the accompanying tools and techniques, may be more meaningful than utilizing "hand-me-down" devices where one has but to pour in the water or press the button properly to operate them. Often the neat case or nicely painted frame or covering of the commercial apparatus hides the real construction and makes more obscure and formidable an already puzzling science principle.

While there obviously are numerous pieces of apparatus and equipment which it is very desirable, if not necessary, to purchase —such as ammeters, microscopes, bunsen burners, vacuum pumps, thermometers, and electric motors—it is surprising how many pieces one can make or improvise or have constructed by pupils. Whether the teacher- or pupil-time could be spent to better advantage is not the question here—much of the useful and needed apparatus for general science, biology, physics, or chemistry can be satisfactorily and inexpensively made, and the making as well as the using of such apparatus can be worth-while pupil experience.

To make such apparatus, whether because of lack of equipment or because the experience in making and using it seems to be particularly desirable, one needs four things not always available in the school science laboratories but not difficult to provide. These are (1) a variety of "raw materials" or supplies; (2) a few simple tools; (3) a suitable working space and arrangements for such "improvising"; and (4) a small working library of practical references.

Variety of "Raw Materials"

When one starts to make provisions for even a small array of teacher- or pupil-constructed devices, he finds need for a relatively wide range and variety of materials. While the usual materials, such as chemicals, glass and rubber tubing, bell wire, flasks, rubber stoppers, and thermometers are needed, numerous other things outside the lists furnished by the laboratory supply companies for the supplies needed to carry out demonstrations and laboratory experiments will be necessary. Aquarium cement, spring brass, Fahnstock clips, asphaltum paint, nichrome wire, ball bearings, DeKhotinsky cement, 6–32 machine bolts, soldering lugs, and copper tubing are only a few which soon are added to the purchase list. When teacher or pupil is making something, particularly during a limited time such as a class period, it is, to say the least, very disconcerting and inefficient to have to lay aside the project for lack of the proper-sized washer or of suitable waterproof cement. The fact that it can be purchased for a few cents at the ten-cent store is not too pertinent when one needs it immediately.

This suggests, of course, that as many as possible of the supplies which may be needed should be anticipated and that a sufficient store be on hand for immediate use.

Often it is possible for the science teacher or pupils to obtain certain supplies from other departments in the school, particularly the fine- and industrial-arts areas. While this may be satisfactory for emergency needs, it obviously is not a long-time policy. If one needs a little glue, or stain, or angle iron, or show-card ink, he usually wants it immediately and wants to use it where and how it

seems most suitable for his particular project. Frequently, overlapping of the needs of teachers from two or three different areas for the same supplies suggests the possibility of pooling orders so that advantage can be taken of lower prices for quantity lots.

A great deal of scrap material can usually be used in constructing and improvising science apparatus. The scrap boxes of the woodworking and metal-working areas of the industrial-arts department often contain small pieces of wood, of copper, brass, and iron sheets or strips, of metal pipes or tubes, of angle iron, and even of wire that are large enough for use in science devices. Bottles, jars, tin cans, and round and rectangular cartons may usually be obtained from the cafeteria or home-economics department. Mailing tubes useful for winding coils or optical devices can be saved by the offices.

Ten-cent stores, hardware stores, auto-supply stores, as well as electrical and radio stores are quite obviously good sources of useful materials at relatively low cost. Junk yards, garages, and gasoline service stations also offer possibilities for picking up old generators, storage batteries, transformers, induction coils, thermostats, cutouts, tubes, ball bearings, and wire. While most of these may not be in a suitable condition "as is," some may be repaired or rebuilt into other devices, or parts and supplies may be salvaged from them, particularly wire. Pupils often show considerable talent and resourcefulness and prove to have "contacts" which the teacher does not have, if encouraged to bring in such types of supplies.

A workable scheme for helping to keep track of such a wide range of supplies is to have each item listed on a single 3 x 5 or 4 x 6 card, arranged in an alphabetical file. On this card can be indicated suitable places where it may be obtained or purchased, the usual unit used in ordering (lb., doz., qt., liter, gross), the unit price, the amount on hand at a certain date, and any other pertinent data. As one continuously adds to his list of supplies, he can write down each item needed on a card, and later file these cards (or make out a new, neater one) in the permanent supply card file. If one has sufficient drawer or cabinet space in which to store such supplies, the location of each item can be added to the

other data on the file card, or a separate file or list giving the location may be kept. The latter is particularly useful for pupil use or where other teachers and classes make somewhat irregular or infrequent use of these materials.

A Few Simple Tools

One cannot make very satisfactory progress in constructing equipment or modifying salvage parts into useful science apparatus without the use of at least a few tools. Perhaps it is obvious what most of these are. Handsaws, including crosscut, rip, back saw, coping saw, and hack saw; claw hammer, ball-peen hammer; mallet, brace for bits, hand drill; wood and cold chisels; screw drivers; folding rules, gas pliers; wire-cutting pliers; tin snips; try square; wood and metal files; planes, auger bits; drills; wrenches; and vise are almost minimum essentials. To this should be added such nearly indispensable items as soldering irons, small c-clamps, oil stones, taps and dies for at least 6–32 and 8–32 machine threads, and emery wheel. Certainly most, if not all, of these should be made available in the science laboratory or shop. One should not rely on borrowing them from the industrial-arts room. For the relatively infrequent use of a few special tools or of power tools, one might count on the usual accommodating co-operation of the school shop.

The small expense involved in providing such a suggested minimum list of tools is more than justified by the savings resulting from the construction of science apparatus and by the learning experiences of pupils and teacher.

Suitable Working and Storage Space

Supplies and tools are of little use without a suitable place to use them. This certainly does not need to be large or elaborate. It may be a small closet or room near the science laboratory. The science preparation room might be arranged for this purpose. Storage and working space might be provided in the science laboratory. Or a combination of two or all of these might be the appropriate solution in some situations. One or more tables to which a vise could be attached, with a work table or two along the wall

where outlets for electricity, gas, and water could be provided, would pretty well take care of the needed working space.

The problem of storage, because of the large number of small items, seems best solved by the use of a number of small drawers or boxes, or other type of containers, such as glass jars, or a combination of these. If cabinets or shelving rather than a fairly large number of small drawers are available, the use of a series of different-sized drawers may be quite satisfactory.

With whatever arrangement for storage that is provided, labels should be used on each drawer, box, or container. It is much better to letter them with a lettering pen in rather large size than to type them. The provision of an alphabetical index, either on cards as previously suggested or typed or mimeographed, is a device which will save much time and confusion in finding and replacing supplies. This is particularly valuable where different groups of pupils make use of the supplies semester after semester —though even the teacher, who set it up in the first place, may forget whether the sealing wax was placed in the box with the paraffin wax and candles or in the one with glues and cements.

Practical References

Unless one has a very great deal of resourcefulness and previous practical experience with tools and devices, he will find considerable need and use for references which give suggestions on what to make and how to make it. Such references are particularly needed if pupils participate in working on these or related projects. One will need at hand references which will give information about such things as kinds of glue for certain purposes; chemical formulas; size of drills; size, resistance, and current-carrying capacity of wire; circuits for different devices; how to drill a hole in glass; soldering, brazing, polishing. The teacher with a little ingenuity can, of course, make plans for his own improvisations, modifications, and special apparatus. However, over a period of a hundred or more years a vast array of interesting and useful inexpensive demonstrations, laboratory experiments, projects, and special equipment have been devised and described by resourceful teachers. Recent as well as back issues of such a magazine as

School Science and Mathematics contain a wealth of suggestions on this phase of science teaching. The catalogues of apparatus companies are particularly suggestive. Many trade journals also contain suggestions for making useful apparatus, as do popular science magazines. Of course, there are also a great many books which treat one or more aspects of this practical phase of constructing devices and working out demonstrations.

VISUAL EDUCATION

TECHNIQUES FOR USING BULLETIN BOARDS

A well-constructed bulletin board can provide variety and interest in learning experiences. If bulletin boards are used for the sole purpose of posting pictures to make the room attractive or displaying administrative notices, their function in learning situations is extremely meager. Bulletin boards may be constructed to teach scientific facts, to review information which has been learned, to test the information students have, to make application of information to new situations, to extend students' knowledge of various topics, to apply the information of topics to current events, to display student work for the purpose of developing standards for the group, or to present information about topics not included in the textbook. A variety of pictures, diagrams, charts, drawings, and other kinds of material may be used to construct bulletin boards. A bulletin board should always have a topic, a problem, or something to emphasize the main idea it is organized to teach.

Example of a Bulletin Board Used for a Demonstration

The teacher posted on the bulletin board a variety of labels from different kinds of plant food products which were designed to be dissolved in water. The claims of the products were emphasized by an arrow which pointed from each label to a test tube that contained a solution made with the product. A wheat seedling had been placed in each one of these test tubes. One of the test tubes contained tap water for a control. Behind the test tubes graph paper had been mounted so that the length of the roots could be recorded each day. The questions on the bulletin board were these: "What plant food product would you purchase?" "What is the effect of plant food products on the root growth of plants?" "Are the claims of the advertisers justified?" It was soon apparent which plant food products were the most valuable to use to stimulate root growth in plants.

Example of a Bulletin Board to Be Used to Review Information

The following pictures were placed on the bulletin board by one teacher: pictures which showed light coming from luminous objects; pictures of light coming from reflected objects; pictures of objects which are useful to man because they reflect light. Students were asked to do these three activities: (1) list the luminous objects, (2) list the objects which are sources of reflected light, and (3) describe why the objects which reflect light are useful in this community. The students corrected their own papers by reviewing the textbook.

TECHNIQUES FOR USING CHARTS

The publishers of charts try to get as much information as possible upon one chart so that it will be useful to a variety of different teachers and in a number of different situations. When charts are used as a source of information, students should recognize that the title of the chart describes its purpose. They should have emphasized for them the part of the chart which provides information for the topic they are studying. Charts may be used to review information, to teach new information, or to apply information already learned to new situations. Some teachers have used charts as a testing device.

If diagrams or figures on charts are so small that it is difficult for the class as a whole to see them, it is better not to use the charts unless provision is made for each student to see. An opportunity should be provided for students to examine and discuss charts before they are used as a part of the teaching technique. Students may do this before or after class, or time may be provided in the class for students to study the charts while they are working individually on exercises in the Companion Book. It is essential, if charts are to be learning activities, that the students do the thinking and the work with the charts. The teacher who lectures, points out, and has the best view of the chart is the one who is really benefiting from the experience. The students should do the answering of questions, the pointing, the identifying, and the recording of information.

SUGGESTIONS FOR A CURRENT FILE

At the beginning of the year the teacher should organize a file according to the topics in the book which are to be studied. Students should be encouraged to contribute clippings, pictures, articles, and other material to this file. As the material in the file is used it should be evaluated so only the best things are retained. The file will be small at the beginning but it will be an accumulative process which can result in much valuable material to be used on bulletin boards. Many parents are happy to contribute old issues of their magazines for this purpose.

TECHNIQUES FOR USING DEMONSTRATIONS AND EXPERIMENTS AS LEARNING ACTIVITIES

For some reason many science teachers prefer to think of demonstrations and experiments as opportunities for them to display their skills at manipulating apparatus and "making things work." The students sit in boredom while the teacher has all the excitement. If demonstrations and experiments are for the students and for their learning, then opportunity should be provided for them to participate in them. Not every demonstration or experiment can be a success, and teachers should not feel embarrassed or inadequate if the demonstration fails; neither should they chastise students for failure to have a successful demonstration or experiment each time. All individuals have a natural curiosity to feel, smell, taste, hear, and see. Whenever possible the five senses should be allowed to operate for the gathering of information. The important points of emphasis are care, caution, and wisdom in deciding what to touch, what to smell, what to look at, what to taste, what to listen for, and what to feel. It is very easy to develop within students a pride in the care of equipment if they are allowed to satisfy their curiosity in connection with it. One science teacher said that she was never able to use the laboratory provided for her science class because the students did nothing in the laboratory but destroy equipment and waste their time. The wrong standards had been developed with these students and the purposes of demonstrations and experiments had never been

clearly explained. Perhaps the demonstrations and experiments selected for them to learn by were meaningless and useless to them. Students enjoy figuring out what to do with materials if they are given the opportunity and if it is clear to them the purpose for which these materials are to be used. A good science teacher will often introduce a demonstration or experiment by asking the students to identify the materials that are being used. Before anything is done students should have a knowledge of the things that are used to accomplish the demonstrations and experiments. The second thing the science teacher does is to explain what kind of information can be obtained from the demonstration and experiment or to write on the board the questions which the demonstration will help to answer. When these things have been done he may ask the students this question: "How can the materials we have be used to answer our question?" Students enjoy trying out their ideas in the arrangement of the equipment. If the arrangement a student makes is not identical to, but as good as the one the science teacher had in mind, the student should be allowed to use his arrangement and he should be complimented for thinking of it.

The demonstration or experiment should be done once so that questions which students have may be answered. The teacher will discover if it will work and the excitement of watching will be over. It should then be performed again so that observation may be directed to certain results which will help to answer the problem. A good science teacher, in addition to using the demonstrations and experiments suggested, will think of similar demonstrations and experiments which emphasize the same information. An excellent exercise to discover if students can recognize the similarities in many different kinds of demonstrations and experiments can be done by providing a series of demonstrations and experiments which emphasize the same point. The students are asked to record on a chart what is similar, what is different, and the result of each demonstration or experiment. The result should be stated in the form of a scientific fact. In addition to these things a student should be urged to write the answer to the questions: "What happened?" and "Why did it happen?" Science

teachers who use this technique discover that some students can recognize only the differences which exist; others are able to recognize the similarities; and some are immediately able to recognize the relationships which exist among all the demonstrations and experiments.

TECHNIQUES FOR USING FIELD TRIPS AS LEARNING ACTIVITIES

Field trips often become pleasure excursions that are more like picnics than they are like learning activities for the purpose of getting information. Before each field trip students should make a list of the standards they have agreed to adopt during the trip. At the end of each trip they should evaluate how well they have achieved those standards. They should have a list of questions which are to be answered during the field trip or they should know that the purpose of the field trip is to see what can be discovered and to bring back information which will help to answer questions.

Science teachers often expect the impossible on field trips. They expect students to be quiet, to listen, and to be interested in things the teacher is interested in. If the field trip is of importance to the student and he is interested in getting the information that can be acquired by the field trip, the teacher will not have to worry about noise or disturbing activities. The important thing is to listen to what children say when they talk rather than to concentrate merely upon the fact that they are talking. Children can contribute a great deal of education to each other if teachers don't prevent the process. Field trips should be enjoyed. There should be some opportunity to be informal and to make contributions to the enjoyment of living as well as to the intense emphasis upon learning from observation. During a field trip a teacher is often able to sit down with his students about him and to make suggestions and discuss behavior important to the group that it is not possible to discuss in the classroom because of the formal situation. A teacher must expect active youngsters to be active when they are outdoors. He should also expect them to

learn many things in addition to those for which the field trip was planned.

When field trips are taken to places in the community and people are asked to devote their time to making explanations for students, the group should not tolerate a discourteous student. Many such field trips are a waste of time because students cannot hear, because the trips last too long, because the students cannot concentrate upon what they are seeing, or because the person who is answering the questions talks "above the heads" of the students. A well-organized field trip for which the teacher has made previous preparation by discussing with the person in charge the kinds of students who will attend, the information that they wish, and the difficulties of the physical layout in which the field trip is to be taken will be rewarded by having a real learning activity. Excursions in the same pattern as a Cook's Tour are useless in a science class. Groups of students can take these excursions on week-ends without wasting the time or the effort of the science teacher.

TECHNIQUES FOR USING FILMS

Films are often used as an entertainment feature in education. If films are to contribute information which will help solve problems, teach science subject matter, or apply subject matter to many situations, the teacher must make careful preparation for the use of this kind of visual material. A teacher should, if possible, preview the film before it is used with the class. If it is impossible to do so, the class and the teacher may preview it together, which will mean that it will have to be shown twice. Following the preview, the teacher should make clear the part of the unit to which the film is related. He should also suggest the kind of information that can be acquired from the film. He should make a list of questions to guide the observation of children as they look at the film. After the film has been shown, opportunity should be given for the students to answer these questions. If possible, they should see the film again so that they can evaluate the correctness of their own answers. If the film is used for recreation and enjoyment of the class, these purposes should be apparent to the class before the film is shown.

Films for How and Why Conclusions

In the chart below are listed certain selected films which may be useful to help teach the information in the various units. Although the films are listed for separate units, they may be used as desired by the teacher. The numbers to the right of the titles of the films refer to the list of companies which follows. Only one company is listed as a distributor for each of these films. Most of the films, however, are available from ten or more distributing companies.

Unit	*Film*	*Company*
The Human Body	Heredity	4
	Unseen Worlds	5
The Nervous System	Nervous System	4
Soil	Formation of Soil	4
Plants and Animals for Food	Green Plants	4
	Born to Die	6
Scientists Combat Disease	Bacteria	4
	Body Defenses Against Disease	4
Radio Broadcasting	Receiving Radio Messages	4
	Sending Radio Messages	4
Bones	Posture and Exercise	4
Soil Conservation	Conservation of Natural Resources	4
Our Water Supply	Properties of Water	3
Air Transportation	Air Flow	2
	Air Resistance and Streamlining	1
	Forces Acting on an Airfoil	2
	Lift	1
	Properties of Air	1

Film Distributors

1. Bray Studios, 729–7th Avenue, New York 19, New York.
2. Castle Films, 30 Rockefeller Center, New York 20, New York.
3. Coronet Instructional Films, 65 E. S. Water Street, Chicago, Illinois.
4. Encyclopedia Britannica Films, Inc., 20 N. Wacker Drive, Chicago 6, Illinois.
5. Ganz, William F., Institute of Visual Training, 40 E. 49th Street, New York 17, New York.

6. General Motors Corporation, 3044 W. Grand Blvd., Detroit 2, Michigan.

TECHNIQUES FOR USING LANTERN SLIDES AND FILM STRIPS

Lantern slides and film strips may be used by a teacher for several purposes. They may be used to review important ideas, to test the comprehension of students, or to teach a particular concept in science; or they may be used as new situations to which students must apply information they have learned. As the slides are viewed by the students, the teacher should have prepared a series of questions to direct the attention of the students to the main ideas which can be obtained from the slides in relation to the problem or topic which they are studying. Many slides shown in science classes are meaningless to students because the students do not know the relationship of the object they are looking at to the things they have been studying. This is particularly true of cross sections of tissues. One other difficulty is the concept of the relationship of size of the actual object and the apparent size of the object as shown on the slide. A teacher should always emphasize the degree to which the object on the slide has been magnified. Many science students make their own slides. Kits for this purpose can be obtained from many of the supply companies. One of the dangers in using visual materials is that students become so interested in certain ideas that are unrelated to the problem that the information is never obtained which is needed to help them with their problems. If there is a variety of questions which are "off the topic," the teacher should provide a special time to answer these questions, or the questions may be answered at once in order to satisfy the immediate curiosity and the slides shown another time so that the students can obtain the information they need.

TECHNIQUES FOR USING MICROSCOPES, MODELS, AND OPAQUE PROJECTORS

The directions given for the use of slides, charts, films, and bulletin boards are applicable to the use of microscopes, models, and

the opaque projector. If a teacher has very little money to spend on equipment for the science room, an opaque projector in which slides can also be shown is one of the most valuable pieces of equipment to enrich the learning activities of students. Pictures in books, printed material, diagrams, pamphlets, and many other kinds of material can be projected upon the wall with an opaque projector. In the junior high school, it is not essential to have a microscope for each student. The skill required to operate a microscope can be learned when the student takes other high school sciences. A few microscopes which can be used to show certain prepared slides which are most meaningful in relation to the units can be set up in the room and students may view them under the direction of the teacher while other students are working on exercises in the Companion Book. A microscope which may be adjusted and used with a light bulb to project a slide upon the screen is most useful for large classes. Many models are not valuable for work in science classes in junior high school unless they are sources of information which cannot be obtained in any other way. They are very expensive and a teacher should be cautious to buy only those which are most essential. It is often possible to use actual material rather than models.

TECHNIQUES FOR USING INTERVIEWS

Many science teachers feel themselves successful if they are able to get out of teaching classes by having a variety of guest speakers. The purpose of the speaker is to "take up the time." Before a speaker comes to a group he should know the questions that the students want answered. The teacher should have discussed the answers with him so that he can make suggestions and should have briefed him as to the background of the students and their abilities to understand what he is saying. The purpose of interviews is not to compliment the person who comes but to provide information that the students could not otherwise obtain. The class should always send a letter which thanks the speaker for contributing his time. The teacher should make an effort to thank him personally. The teacher should also carefully evaluate his effectiveness with the group. Those speakers who are ineffective should not be asked to return.

Students should have an opportunity to discuss with the teacher the information that should be recorded from the interview. While the speaker is there they should listen and ask questions if he permits, but their time should not be devoted to the taking of notes since junior high school people have not developed the skill of concentrating upon note-taking and what the speaker is saying at the time. It is better for them to concentrate on what the speaker is saying. The teacher should be the one who does the note-taking so that he can re-emphasize the main points which the speaker makes.

TECHNIQUES FOR USING LIVE MATERIAL

A science teacher who stimulates genuine interest and curiosity in the environment finds himself with a great deal of live material in his classroom. One of the most repulsive things in science rooms is the amount of dead material that is in various stages of decay and putrefaction. Containers become filthy and impossible to clean. The room is repulsive to the students who must study in it and to others who may come into the room. The purpose of keeping live material in a room is not to discover how long it must be dead before someone will remove it, but to enjoy and learn through observation while it is alive.

In schools where money is not plentiful and it is impossible to buy a great deal of equipment which facilitates the handling and care of live material, a teacher and the students may have to make their own containers. Some science classes have used science programs in the community as a means of raising money to purchase equipment essential to the care of living things. Any reputable biological supply house lists in its catalog a variety of aquaria, terraria, and cages.

Any living thing kept in a science room should have adequate air, water, sunlight, food, and a clean place to stay. If such things as pigeons, chickens, or ducks are to be kept in a room, their cages should be cleaned regularly and they should be provided with the essentials for healthy bodies. Rats, mice, guinea pigs, hamsters, and rabbits need daily care. Rather than having too many things in the room at once, so that all the time of the science

period is spent in the care of them, it is better to have a pet show or a demonstration of live material once a month or once a semester. Many of the biological supply houses have leaflets which will be sent free of charge to inform the teacher of the best ways to keep live material in the room. Students should never be permitted to tease, to be cruel to, or to destroy live material.

A special cabinet, table, or section of the room should be devoted to a display of the material that accumulates. By the end of the school year a vast amount may be on hand. Teachers who try to save all the material that is brought in usually find they do not have sufficient room for its adequate preservation. It is better to clean house at the end of each year and to start afresh with new collections which are meaningful to the students who bring them in, rather than accumulating vast amounts of material which are available each year in great quantity. This is particularly true of rocks and insects.

A great deal of teaching of scientific information can be done through the use of live material if a teacher provides the opportunity for it. Questions such as these can be answered by observation:

1. What are its characteristics?
2. What does it eat?
3. Where does it live?
4. What other animals is it related to?
5. What do we use it for?
6. Is it harmful or beneficial to man?
7. What do the young look like?
8. In what other parts of the country is it found?

Children may also be stimulated to write individual reports or to do individual research problems about the live materials. If a student goes to the trouble of contributing something to the science room, he should have an opportunity to tell about it. In the junior high school he should add to the information that he has acquired incidentally, and obtain information that is the result of special interest in the material.

TEACHING PROCEDURES

SUGGESTIONS FOR TEACHING THE UNITS IN HOW AND WHY CONCLUSIONS AND THE USE OF THE EXERCISES IN THE COMPANION BOOK

INTRODUCTION

The first exercise in the Companion Book which includes pages 1 through 4 is designed to set the theme of How and Why Conclusions. How and Why Conclusions is the eighth-grade book in a series of science textbooks which begins with a pre-primer. Beginning with the fourth-grade book, certain characters were introduced as members of a "How and Why Science Club." The children and the teachers and their friends were from many parts of the United States. How and Why Conclusions is the last book in this series which uses the children of the "How and Why Club" and their experiences as the basis for some of the units in the book. The last book in any series should be an introduction to further individual study and a summary of previous science work. The title of the book was chosen to indicate conclusions that are possible to make if one has had cumulative experiences in science. The cumulative experiences, in addition to forming the basis for conclusions, also form the basis for continuing to learn about science. Therefore, the first exercise in the Companion Book is titled, "Science in the World Today." Its emphasis is upon the problems which scientists are currently trying to solve.

Since one of our great, daily sources of current information is the newspaper, and since we know that most people will confine their reading material to a survey of their local daily newspapers, it is wise that the students use this as an introduction to current scientific problems. On the first three pages of the Companion Book students are asked to paste clippings which tell about the new things that are being discussed in the field of science. The teacher should ask students to outline the words in the headline of the article which indicate that it is about a new development in science. These underlined words will form the

basis for the summary which is to be made at the end of this year's study of science. The directions in the exercise suggest that the information be checked with an accurate source to determine if it is correct. There are several ways to encourage pupils to do this. One is to check with current magazines that report the work of scientists. The *Science News Letter* is one of the most reliable sources for pupils of this age. If the article mentions a scientist who is working on the problem, pupils may write to him and ask questions which they have about the article. These questions may be raised by asking pupils to compare articles in different newspapers which are written about the same topic. If the teacher knows scientists at any one of the universities, she may ask the pupils to write to them for verification of information in the article. The school librarian may be able to suggest authoritative pamphlets on the same topic written by experts in the field of science. Any one of these methods for verifying what pupils read will prove valuable in stimulating questions and eagerness concerning the accuracy of printed material. Probably many of the articles will be in the area of health or conservation. There may be state officials or local doctors who can verify these accounts. It should be remembered that newspapers report as accurately as possible considering the amount of time and information they are able to gather about the topic of the article. The student should consider newspaper articles as indications of problems that are important. It might be interesting if a person from a newspaper office could be secured to talk to the students about the problems of reporting scientific events in a newspaper.

Many children believe there is nothing new under the sun. This is one method to make them aware of the problems which scientists are trying to solve. Throughout the year there should be opportunity for members of the class to report and discuss the articles they are pasting on the pages of a notebook. If additional space is needed pupils may start individual notebooks.

"Science in the World Today" includes the topics listed on pages 2 and 3 of the table of contents for HOW AND WHY CONCLUSIONS. There is not a topic in this list which does not contain current challenging and unsolved problems for scientists. The basic ideas presented about each one of these topics help a student form,

through many experiences, the information and the skills necessary to appreciate the problems in these areas. Each one of these can be expanded indefinitely. As was true in the seventh-grade book, there is no logical sequence in How and Why Conclusions. The pupils who study this book are still in junior high school and usually have not specialized vocationally or educationally. Their interests are many and varied and it is essential that a teacher present each one of these units during the year so that special interests of different students are not neglected.

The Companion Book has been written to make possible experiences which continue the development of skills begun in the seventh-grade book. Many of the skills developed previously are useful in doing the exercises in this Companion Book. These exercises were not written to accompany any other textbook of science for the eighth grade. They were written to be included as an integral part of the teaching methods for the presentation of this material. Many times throughout this Companion Book problem solving, attitudes, reading skills, the accurate recording of information, experiments, observations and demonstrations are incorporated in the exercises to continue the development of these skills.

It is suggested that the teacher read the text and the exercises which accompany it before planning the year's work. The suggestions made in the teacher's manual may be helpful to teachers who are seeking a variety of ways to make the teaching of science dynamic and special for different units.

THE HUMAN BODY (Pages 5–15)

Science Concepts:

During adolescence there is greater growth and development than at any other time.
All life comes from life.
New plants come from living plants.
New animals come from living animals.
All plants and animals are composed of protoplasm.
Protoplasm is composed of water, carbon, hydrogen, oxygen, and nitrogen.

Special cells for the purpose of creating new generations develop in plants and animals.
Individuals change most during the first twenty years of life.
Head shape changes as individuals develop.
The sutures of the skull become knitted into solid bone.
Neck muscles develop.
Eye muscles develop.
The size of the liver is changing.
Enough food is stored in a baby's body at birth to last about three days.
Muscles, glands, and skeleton change rapidly.
Bones may grow more rapidly than muscles.
The body uses large amounts of food during rapid growth.
Food provides energy for growing boys and girls.
Rapid growth and development require special care of the body.
Cell reproduction and death rate pass through three phases: they reproduce faster than they die; they reproduce and die at same rate; they reproduce more slowly than they die.
Children inherit characteristics from both mother and father.

Many changes have occurred in the bodies of the pupils since they began the study of science in the seventh grade. Since children develop at different rates it is well to provide opportunity for them to ask questions and to discuss changes which are taking place in their bodies. For this reason there are several units scattered through the book which provide this opportunity for the student and the teacher. The first one is on growth; the second unit is on the nervous system; the third one is on bones; and the fourth one is on the heart and blood. Four times during this year students should have an opportunity just to discuss problems of behavior and physical changes about which they are curious in relation to their own bodies.

The attitudes and the "trend of the discussion" which accompany the study of the first unit will determine to a great extent the attitudes and the trends of discussion for the rest of the year. As with all other living organisms, the science of the human body is one of exchange, transformation, and utilization of materials

and energy. Although this is not developed in the text there are exercises in the Companion Book which emphasize this idea. Note, for example, that on page 9 of the Companion Book the elements, oxygen, carbon, hydrogen and nitrogen are discussed in relation to protoplasm. If a student recognizes the fact that the protoplasm in his body and that of other living animals is similar in many respects, certain attitudes that are desirable in relation to the human body as a living organism can be developed. Note also the exercise on page 12 of the Companion Book where this idea is furthered by asking children to compare protozoans with children. The comparison is on the basis of the elements in protoplasm. In addition to these ideas, another exercise on page 10 of the Companion Book presents the idea of the life span through which a person lives. This life span is likened to one hour and each part of the life span to so many minutes of that hour. Children have always been interested in questions like this: "If you were to live your complete life in one hour how many minutes would you be a baby, how many minutes would you be a child, and how many minutes would you be an adult?" This same kind of chart can be made for the life span of other animals. All these ideas are introduced by the pictures which appear on pages 8 and 9 of the textbook. During the discussion of these pictures there is the possibility of further developing sensible attitudes in relation to the human body as a living organism. In addition to this idea there is also developed the concept that there are relationships which exist among living organisms and nonliving materials. Pages 5, 6 and 7 in the Companion Book are designed to emphasize this particular point.

It would be wise for the teacher to read through the material with the children, discuss it with them, discuss the drawings and the diagrams, and help them with the exercises in the Companion Book. Doing this as class work and cooperating in the suggesting of answers and ways to do the exercises help to start the year in an informal and pleasant way. Any questions which the teacher is not prepared to answer should be carefully noted and assurance given to the pupils that their questions will be answered when there is an opportunity to do so. Many of the questions

which they ask may be answered during the year as other units in the textbook are studied. Since many of the pupils probably have small brothers and sisters or members of their families who are in elementary school, it may be possible to do many things with this material to help them understand what is happening as these children grow and develop.

The last paragraph on page 7 of the text contains an important idea which is often neglected by teachers in the classroom. If the study of science results in a purely analytical attitude toward life and human relationships, based upon a knowledge of protoplasm and the flow of materials and energy through it, a part of education has been omitted which is essential to the development of good scientists, capable people in a community, and the improvement of human relationships. Since one of the distinguishing features of the living organism called man is his ability to make choices, there comes within his jurisdiction the control of himself and other people. These choices, these decisions, their effects and the reactions to them are things that cannot be seen or analyzed with a microscope. Growing and developing as physical organisms may be inconsequential if emotional maturity and spiritual growth and development do not accompany the physical changes which take place. It is essential then that a teacher develop with his students the idea that growth of a human organism includes growth in many different directions. These kinds of discussions cannot be outlined so that they are applicable to each group of students or for each teacher. Teachers must decide the best way to discuss these points with their students. Help can usually be obtained from other members in the community or from members of the school faculty who have been successful with these kinds of discussions. Children are seriously and intensely interested in teachers who have developed standards which they believe are important. No student should leave a classroom without knowing what standards his teacher believes to be important. If the greatest standard which the student believes the teacher has emphasized is such a one as "be quiet," "be still," or "don't chew gum," there has been omitted an emphasis upon lasting standards of human relationships suggested in the last

paragraph on page 7 which are vastly more significant to the development of wholesome personalities, and are of greater interest and consequence to students than the petty directives we often give them by which to guide their living.

Suggested Activity No. 1:

Collect as many pictures as possible of young babies and their parents. Compare these pictures to the one in the upper right-hand corner of page 11 of HOW AND WHY CONCLUSIONS. What are the main differences in the pictures and what are the similarities?

Suggested Activity No. 2:

Observe a baby for one or two hours a day. Record the age of the baby; record each movement that he makes. Write your suggestions as to why you think he makes the movements he does.

Suggested Activity No. 3:

If possible do the same thing for a child in each one of the grades in your school. Compare the different kinds of activities that each one exhibits. Are there similarities in their motions? What are the greatest changes that are noticed? Why do you believe these changes occur?

METALS IN THE EARTH (Pages 16–35)

Science Concepts:

Metals have properties and characteristics which distinguish them from other materials.
All metals may be melted.
Most metals are solids.
Some metals are liquids.
Metals are malleable.
Metals may be drawn into wire.
The densities of metals vary.
All metals come from the earth.
Some metals come from the earth's crust.

Some metals come from the ocean.
Some metals like gold, silver, and copper are found in pure form.
Some metals may be found as chemical compounds.
Some metals—gold, silver, copper, tin, zinc, lead, aluminum—are elements.
Metals react differently with other substances.
Gold and platinum are inactive.
Copper and lead are moderately active.
Sodium and potassium are very active.
All pure metals can be prepared in the laboratory.
The heaviest metals are attracted more by gravity.
The outer layer of the earth is composed of granite rock, sedimentary rock, lava, and soil.
Metals are found in the outer layer of the earth's crust.
The shifting of the earth's crust produces heat.
Certain chemical elements combined when rock was molten to form mineral desposits.
The crystals of different metals are different.
Metallic minerals yield metals such as copper, iron, and zinc.
Non-metallic minerals yield such things as quartz.
The formation of metals has required long periods of time.
Man employs many methods to obtain metals he uses.
Some of the precious metals like gold are found in a free state and are obtained by simple physical processes.
Veins of metals vary in size from a few inches to several feet.
Some metals are removed from the earth by drilling holes deep into the earth.
Many ores exist in irregular masses of rock.
Geologists can determine when minerals were deposited.
Different conditions of the earth's surface produce different kinds of mineralization.
The energy of explosives may be used to break rocks.
Nitroglycerin produces explosive energy.
Ore-bearing rocks are crushed for refining.
Some ores require chemical processes to separate the metal.
Metals such as silver, copper, lead, gold, and zinc may be separated from their ores because of density.

Heat and chemical and electrical processes are used to extract pure metals.

Since the students and the teacher have been working closely together in discussion during the last unit, the students will probably enjoy working by themselves for the next unit. Ask the students to read the material in How and Why Conclusions on pages 16 through 35. After they have read the material once have them read the exercises in the Companion Book on pages 13 through 16. Students should now have the habit of surveying the work that is to be done and of forming plans which will prevent a waste of time. When they are familiar with the material in the textbook and the kinds of things they are expected to do in the Companion Book, they may plan to complete the exercises in any order which they find most efficient for them. These exercises include learning the properties of materials, increasing vocabularies, using reading signals, and recording information on maps which they will use later to make conclusions.

Suggested Activity No. 1:

Make a bulletin board with pictures similar to the one on pages 16 and 17. Make arrows which are colored to indicate different kinds of materials. Point these arrows to places in the picture where these materials have been used by man in building his communities.

Suggested Activity No. 2:

If encyclopedias are available for children to use they may enjoy making reports and drawing diagrams, similar to the one on page 33, which show how different materials are prepared for use.

Suggested Activity No. 3:

Many companies which sell or procure materials for their products have free materials which they will send upon request. Students may write for these booklets and exhibits.

Suggested Activity No. 4:

A map of the community may be made on the bulletin board to

be placed under a map similar to the one on page 35. Arrows from the world map may be used to point to places in the community where these materials are used. *Natural History Magazine* had a series of articles which told about some of the more important materials that man uses. If these magazines are available or can be obtained from second-hand stores in large cities, they are a source of excellent photographs, pictures, and diagrams.

HOW MAN USES METALS (Pages 36–45)

Science Concepts:

Blast furnaces are used in the production of iron.
During the refining of iron many useful by-products are produced.
Cast iron is hard and brittle.
Steel is a form of iron.
Steel and cast iron are different because of the different amounts and kinds of carbon used.
The quality of steel depends upon the materials mixed with it.
Copper is separated from its ore by the application of heat.
Pure copper is obtained by the electrolytic process.
Copper is used for electric wires and pipes.
Brass and bronze are alloys of copper.
Brass is an alloy of copper and zinc.
Bronze is an alloy of copper and tin.
Monel metal is made of copper and nickel.
Copper is poisonous to some living organisms.
Aluminum is separated from its ore by electricity.
Magnalium is an alloy of magnesium and aluminum.
Duralumin contains aluminum, copper, manganese, and magnesium.

On pages 36 through 45 of How and Why Conclusions the application of the ideas in the first section are discussed. Ask the children to read this section and to list sentences which help to answer the problem: "How does man use materials?" Ask them to underline the words in each sentence which describe a use that man makes of materials. After the words have been underlined,

have the students write a paragraph in which these words are used to answer the main problem. The exercise on page 17 of the Companion Book emphasizes the changes which must occur as materials are prepared for use.

After the students have written the paragraph referred to above, they should re-read the unit to select specific facts in answer to the following four questions:

1. What four materials are used in the process of making iron? (iron ore, limestone, coke, hot air)
2. What three things are produced as a result of the process? (carbon monoxide, melted iron, slag)
3. What two products are finally made? (cast iron, steel)
4. What are four uses made of these products? (cylinder blocks for engines, railroad car wheels, parts for farm machinery, sewer pipes)

Arrange the answers to these questions in chart form. Make a similar chart for steel, copper, and aluminum. When the four charts have been completed, answer these two questions: What is similar about these charts? What is different about them?

Make a bulletin board with pictures and symbols to illustrate the four processes.

Suggested Activity No. 1:

Make a special report of one other process that is used to create utensils that are used in the home.

Suggested Activity No. 2:

List as many things as you can that are used in the home and the materials they are made of.

Suggested Activity No. 3:

Ask salesmen for different kinds of cooking utensils to explain to the class the advantages of having these made of the materials that each company uses.

Suggested Activity No. 4:

Do the experiment on electroplating on page 18 in the Companion Book.

MODERN HEALTH PRACTICES (Pages 46–57)

Science Concepts:

Micro-organisms cause most diseases.
There are two kinds of micro-organisms: plant and animal.
Bacteria, yeast, and molds are plants.
Protozoa are animals.
Viruses cause disease.
Viruses are protein molecules.
Micro-organisms must take in food and water, reproduce, and give off waste.
Micro-organisms live only in moist places such as in the body, garbage, refuse piles, and dirty corners.
Micro-organisms must be transported by wind or some object.
Drugs and chemicals may either kill or stop reproduction of micro-organisms.
Micro-organisms produce toxins.
Micro-organisms may cause endotoxins in the body.
White corpuscles destroy micro-organisms.
Body cells produce antibodies.

The unit on modern health practices includes many essential ideas in relation to first aid. This unit offers an excellent opportunity for pupils to develop a program which can be used to instruct children in the elementary school about health practices that are important at any age or grade level. Divide the class into committees. Have one group work upon wounds, one on burns and scalds, one on frostbite, one on cleanliness in the home. Have them read the material in the textbook on pages 46 through 53. Have them do the exercises on pages 19 through 22 of the Companion Book. Ask each group to plan a series of demonstrations which will teach to younger children the information that is presented in these exercises and this part of the unit. Invite the younger children to the classroom, give the program in assembly, or go to an elementary schoolroom to present the program.

The information on pages 54 through 57 again presents information which is often neglected because of attitudes which children develop in relation to it. The teacher and the pupils should

read and discuss these pages together and do the exercises on pages 23 through 25 of the Companion Book. If possible, invite the school nurse to explain programs for immunization of individuals in the community. Invite a pediatrician to discuss the immunizing program for babies. Discuss the rules and regulations in the school concerning children who have been ill and the things that are necessary for them to do before they are again admitted to school. If the school does not have a school nurse or doctor, teachers often assume the responsibility of the health examination prior to the beginning of each school day. Have the children discuss the symptoms of diseases and the health inspection which the teacher should do in order to protect other children in the room from getting the disease. If it is impossible to send children home again, there are some things that can be done which give a measure of protection to the other children in the room. Have the children list suggestions in relation to this kind of situation. A health survey of the school may be an important feature of this unit. Children should list as many places, practices, and indications of things which would cause the spread of disease as they can find in the school building or on the school grounds.

Suggested Activity No. 1:

List each scientific word in the unit. Tell why you believe these are scientific words.

Suggested Activity No. 2:

Select such pictures as a community, people on a picnic, at a bathing beach, and a person sick in bed. Indicate by labels on the pictures as many of the things in the list above that might be there although you cannot see them.

Suggested Activity No. 3:

Make labels on which are printed the words in the list. Have students place as many of them as they can in places in the room where they are believed to exist.

A CALL ON THE TELEPHONE (Pages 58–77)

Science Concepts:

Transmitter and receiver are the two main parts of the telephone.
The telephone transmitter uses sound waves to vary an electric current.
A galvanometer measures small changes in an electrical current.
Sound waves produce vibrations in the metal disc of the transmitter.
Sound waves are vibrations of air.
Vibrations of the diaphragm cause an electric current to vary.
Carbon grains can conduct electricity.
The resistance of carbon grains depends upon pressure.
Telephone receivers have three main parts: permanent magnet, electromagnet, and diaphragm.
Permanent magnets always exert the same amount of force.
Electromagnets may exert varying amounts of force.
The vibrating metal diaphragm of the receiver produces sound waves.
Chemical energy may be changed to electrical energy to operate a telephone.
Mechanical energy may be changed to electrical energy to operate a telephone.
Electromagnets cause a piece of iron to vibrate in the telephone.
Varying currents cause electromagnets to open and close switches in a dial telephone.

The introduction to the unit on the telephone should begin by a comparison of the picture on page 58 with the picture on page 59. If possible, read to the children from an encyclopedia or an account given in one of the many publications of a telephone company the first conversation which took place on a telephone. From this very simple beginning has developed a communication system which has made possible a picture such as the one on page 58. This picture emphasizes that hundreds of conversations can occur

at the same time, that it is possible to communicate over vast distances, and that even mountains are no longer a barrier to communication by telephone. Many of the materials of the world have been organized to make possible the vast communication system in the United States. Stimulate discussion by questions such as these: "Why is a broken telephone pole shown in the picture?" "Why were the mountains chosen as a background for this picture?" "What is emphasized as the main point of interest in the picture?" At present the success of our communication system depends upon events such as these taking place regularly and promptly as soon as repairs are needed.

On page 61 of How and Why Conclusions there is a list of seven questions. Ask the students to evaluate these problems by the criteria listed below:

1. Is each problem stated in question form?
2. Is each problem clearly stated?
3. Does each problem contain one main idea?
4. Does each problem contain two related ideas?
5. Does the problem emphasize you?
6. Does each problem emphasize the most important idea in the topic?

The children should read the material on pages 61 through 77, then do the exercises in the Companion Book from pages 26 through page 30. The teacher will need to make available the materials for the experiments that are to be done. When the students have completed the exercises in the Companion Book and have read the material in the textbook, they should be able to answer the seven problems on page 61. Ask them to list the information they have gathered, to analyze this information, synthesize it, and make a conclusion for each problem. Have them list these conclusions on one sheet of paper and use them to answer this major problem: Why is it possible to communicate by telephone?

Suggested Activity No. 1:

Visit the telephone office in your community and ask them to explain how it functions.

Suggested Activity No. 2:

Make a diagram which shows where the telephone wires go from a house to the central telephone office. The children will have to follow these wires. This may be a field trip for the whole group.

Suggested Activity No. 3:

The exercise on page 31 of the Companion Book is a review exercise in which the main ideas which have been used in these first units are emphasized by a vocabulary review. The children might write their own definitions of these words and then compare them with the definitions that are found in the book.

FOOD PRESERVATION (Pages 79–87)

Science Concepts:

Two things may cause food to spoil.
Micro-organisms cause food to spoil.
Chemical changes cause food to spoil.
Micro-organisms produce substances which cause chemical changes in food.
Dryness, heat, cold, and salt prevent micro-organism growth.
Some animals may eat carrion.
Many fruits and vegetables are preserved by drying.
Dried foods are dehydrated.
Canning prevents growth of micro-organisms with heat.
Drying and canning change foods.
Cold temperatures may preserve foods without changing them.
Ice cools food because heat is required to melt it.
Ice and water remain at the same temperature until all the ice melts.
Fruit and vegetable flavors may depend upon the sugar they contain.
Fruits and vegetables contain substances which can change sugar to starch.
The liquids within foods contain vitamins and minerals.
Freezing foods may break the cell walls of the food.

Quick freezing prevents rupture of the cell walls.
Evaporating liquid ammonia absorbs large quantities of heat.
Carbon dioxide is a non-poisonous gas which can be changed to a liquid.
Dry ice does not melt.
Dry ice changes from a solid to a gas.

Construct a bulletin board of pictures of as many kinds of preserved foods as you can find. On the bulletin board put a cut-out of the sun, an ice cube, and a fuel. Ask the students to make a list of all foods that you have pictured on the bulletin board. After each food indicate the way it has been preserved. They should write *sun, ice,* or *fuel* after each one of the foods.

Ask students to prepare demonstrations of the way in which each one of these methods is used to preserve food. When they have finished with the demonstrations discuss the answer to this question: "Why do these methods preserve food?" Bring milk in as many different forms as possible, such as powdered milk, condensed milk, pasteurized milk, and raw milk. All but the last of these is an example of one way to preserve food. Ask these questions of the class: "How were these preserved?" "Why would they have to be preserved?" "Can you think of another way to preserve milk?" As a result of these activities ask the children to list questions they would like to have answered in relation to the preservation of food. Put the list on the board and have the children copy the list in their notebooks.

Have the students read the material on pages 79 through 87 and do the exercises in the Companion Book on pages 32 through 34. After they have completed these assignments, have them answer as many of their questions as they can. For those questions which have not been answered ask them to suggest ways to find the information which will answer them. Students should begin to develop a knowledge of sources of information which may be useful to them when they leave school in order to enable them to continue to answer the questions which they may have. Often children ask questions which are impossible to answer. They should be able to recognize these questions and to know why they cannot be answered.

Suggested Activity No. 1:

It is often interesting to invite mothers of some of the children to explain how different foods are preserved in the home.

Suggested Activity No. 2:

Have the children keep a list of the foods they eat which have been preserved and a list of the foods which have not been preserved. What is similar about all the foods in the first list? What is similar about all the foods in the second list? What is different about the foods in each one of the lists? Some children may list grapefruit on both lists. For each one of these similar listings ask them to explain why the same food is sometimes preserved and sometimes sold fresh.

Suggested Activity No. 3:

Visit an ice plant. Ask the manager to explain the process that is used to produce ice. Make a diagram of this process.

Suggested Activity No. 4:

Visit a frozen food locker. Ask the manager to explain how the temperature is maintained so that foods remain frozen. Ask him to describe the difference between the part of the plant which quick-freezes food and the part which keeps food frozen. Ask him how the temperature of the air is measured.

THE NERVOUS SYSTEM (Pages 88–105)

Science Concepts:

The nervous system is composed of neurons.
A neuron is a specialized cell.
Neurons cannot reproduce themselves.
A neuron is composed of cell body, axons, and dendrites.
There are two kinds of neurons, sensory and motor.
Branches of axons and dendrites reach all parts of the body.
Most of the nerve cell bodies are located in the spinal cord and brain.
The spinal cord is in the vertebral column.

The spinal cord is composed of many nerve cell bodies.
Not all animals have nervous systems.
Nervous systems make possible the sense of seeing, hearing, feeling, tasting, and smelling.
Neurons are affected by stimuli.
Electro-chemical changes occur in the nervous system and are transferred to the brain and spinal cord.
The cell bodies are called gray matter.
The axons and dendrites have a white covering and are called white matter.
The human brain is divided into three main parts: cerebrum, cerebellum, and medulla oblongata.
The cerebellum affects the coordination of muscles.
The cerebrum fills almost the entire cranial cavity.
The outer part of the cerebrum is the cortex.
The autonomic nervous system receives stimuli from inside the body.
The autonomic nervous system is divided into two parts, sympathetic and parasympathetic.
The organ of hearing is the ear.
The ear consists of three parts: external, middle, and inner.
The auditory nerve connects the inner ear to the brain.
Sound waves affect the auditory nerve.
The external ear is made of two parts, pinna and auditory canal.
The external and middle ear is separated by the tympanic membrane.
The middle ear is composed of three small bones: hammer, anvil, and stirrup.
The Eustachian tube connects the middle ear with the throat.
The inner ear contains two main parts, semi-circular canal and cochlea.
The inner ear is filled with fluid.
Visual purple is a special pigment in rod cells.
Vitamin A affects visual purple.
The cornea is the clear transparent part of the eye.
The lenses of the eyes are elastic.
The curved lens of the eye bends the light rays.

The iris gives the eye its color and controls the amount of light entering the eye.
The optic nerve connects the retina with the brain.
The retina is composed of nerve cells called rods and cones.

The material in this unit of work again gives an opportunity for children to discuss questions which they have in regard to the functioning of their bodies. As with the unit in the seventh-grade book on food, the emphasis is placed upon the use of scientific information to explain behavior. The relationships among animals is one which children enjoy studying. Most of the material in the textbook is about the human organism, man. The material in the Companion Book on pages 35 through 41 is an application of this information to an understanding of other living organisms. The children should read the material on pages 88 through 105 in the textbook before they do the exercises in the Companion Book.

Since this material is sometimes difficult for children, the teacher should read and discuss it with them. The diagrams in this unit have been included to help the students visualize the relationship of the nervous system to the various parts of the body. It would be well to put this question on the blackboard: "How does my nervous system help determine my behavior?" Each time an idea is learned which will help answer this problem it should be listed on the board. When the list is complete, ask the students to underline the main words in the sentence which are related to the main words in the problem. When these words have been underlined, ask the students to write a conclusion to the problem and to use the words which have been underlined.

When this has been completed, the students should do the exercises in the Companion Book. One explanation is necessary upon the part of the teacher. The six questions on page 35 of the Companion Book will be answered several times during these exercises. *See, smell, hear, feel,* and *taste* are all concepts with which the student is already familiar. The two concepts in question 6, *think* and *learn,* are ones which students may have hazy or erroneous ideas about. Explain to the children that thinking and learning may be done in many different ways, that there are many different levels of thinking and learning. Very young children are

able to think and learn but they do not do it so well and they cannot do so many complicated things as older children can do. The child who makes a toy bridge to place across the river in a sandbox is thinking and learning; the engineer who constructs a bridge to span a river is thinking and learning also. It is not difficult to recognize that these are examples of two different types or levels of thinking and learning. Both the child and the engineer have nervous systems which make it possible for them to think and learn. Other living organisms have nervous systems also, but some of them are less complex than those of man. A frog, for instance, has a nervous system, but it is not so highly developed or so complex as that of a child. For this reason the thinking and learning that a frog can do is on a much lower level than the thinking and learning that a child can do. Whenever we refer to a living organism that thinks and learns, we must remember to describe the kind of nervous system he has in order to determine the level of thinking and learning that he can achieve. The exercises in the Companion Book are designed to show many different levels of thinking and learning that are accomplished by many different kinds of living organisms. The amount of learning that can be done is one of the things which determines the kind of behavior of the organism.

The science vocabulary exercise on page 42 of the Companion Book may be used in the same way as the last exercise of this type.

Suggested Activity No. 1:

A large diagram of a neuron should be placed on the blackboard and students should be asked to identify the parts after they have read page 88 in the textbook.

Suggested Activity No. 2:

Students may write descriptions of the nervous systems in their own bodies.

Suggested Activity No. 3:

Make a list of the stimuli the students receive in one hour.

Suggested Activity No. 4:

Make a list of the responses they make in one hour.

Suggested Activity No. 5:

Observe a pet for an hour. Record the stimuli he receives and the responses he makes. Write a description of his behavior for the hour.

Suggested Activity No. 6:

Make a large outline of pictures of the parts of the eye and ear. Ask students to assemble them on a bulletin board. Write labels of the parts. Have them pin the labels near the parts. Ask students to explain how each part functions.

Suggested Activity No. 7:

Do the same for the diagram on page 91.

SOIL (Pages 106–130)

Science Concepts:

Small rocks are formed by the breaking apart of large rocks.
Most soils are formed from granite.
The most important minerals in granite are quartz and feldspar.
Feldspar may change chemically to kaolin.
A mixture of kaolin and sand produces loam.
Sedimentary rocks may produce soil.
Volcanic ash may produce soil.
Soil is composed of particles of rock, organic matter, tiny living things, water, and air.
Physical weathering describes the processes by which large rocks are broken into soil material.
Changes in temperature cause physical weathering.
Not all particles in a rock expand and contract at the same rate.
Different expansion and contraction rates cause rocks to crack.
The expanding of freezing water in rocks causes rocks to crack.

The enlarging of plant roots causes rocks to split.
Rivers cause the grinding and breaking of rocks into finer particles.
Ice sheets cause grinding and crushing of rocks.
Strong winds produce grinding of small pebbles.
Chemical forces are constantly breaking rocks down.
Water dissolves chemicals, producing acids which react with the rocks.
Decomposition of plant and animals adds to the soil.
Decomposed organic material is called humus.
The ability of soil to nourish plants is called fertility.
The fertility of the soil depends upon chemical contents, minerals present, type of soil, depth of soil, and humus.
The surface of the earth is constantly changing.
Changes below the surface of the earth have caused high plateaus to be ocean beds and ocean beds to be high plateaus.
Erosion is caused by the action of wind and water.
Wind and water may transport soil a great distance.
Lateral moraines and terminal moraines are materials deposited by glaciers.
Soil supplies food, water, and anchorage for plants.
Soil contains chemicals necessary for plants.
Plant foods must be dissolved in water.
Plants absorb food through root hairs.
The concentration of food molecules in root hairs and surrounding root hairs determines the amount of food taken in by plants.
Osmosis is the passage of a liquid through a membrane.
Osmotic pressure is determined by concentration of the molecules.

Many of the exercises in the Companion Book for this unit emphasize soil in the community in which the students live. (See pages 44 and 48 of the Companion Book.) Each time there is an opportunity to relate the work of this unit to things that are happening in the community, the children should have an opportunity to do so. The main problem for this unit should be: "How does

the information about soil help us explain our own community?" As a different experience for the students in the class, ask them to change the information in the textbook into sentences which are about the community in which they live. For example, on page 106 of How and Why Conclusions there is this sentence: "It may surprise you then to learn that much of the material that makes up soil comes from solid rock." In changing this sentence so it helps to explain the community in which the children live it may be stated this way: "It may surprise you then to learn that much of the material that makes up the soil of our community comes from solid rock." Another example on page 107 is this sentence: "Water tends to distribute the particles after the rock has crumbled." In changing this sentence it might read this way: "The water in our Rapid River tends to distribute the particles of soil in our community after the rock has crumbled." As the children read the textbook and do the exercises on pages 43 through 61, the same kind of activity can be followed.

When the students have finished with this unit they should have the sentences which will answer the problem stated at the beginning of this introduction. With this information they would be able to answer the problem and to write a description of their community in relation to the soil that is there. Charts, maps, and diagrams on which information is recorded about the community should be used as evidence to explain the soil in the community.

Suggested Activity No. 1:

Collect pictures which show the results of primary physical weathering and secondary physical weathering.

Suggested Activity No. 2:

Make a series of charts which summarize the information in this unit. Use the charts to explain how soil is being made in your community.

Suggested Activity No. 3:

Obtain some fine gravel which has no organic material in it. Plant radish seeds. Use distilled water to water the seeds. Compare the plants with those grown in soil which contains humus.

How Does the Soil Supply Plants with Food and Water?

The relationships of ideas may be expressed in outline form. A student who recognizes the main ideas and the supporting ideas in his reading material is able to read for information effectively. Have the students make an outline of the material on pages 125 and 126 of How and Why Conclusions.

It is the responsibility of the teacher to have the materials ready so that the experiments can be performed. The exercises on pages 51 through 61 of the Companion Book will help them understand the information and provide evidence with which to answer the main problem. The exercise on pages 58 and 59 of the Companion Book may be done by each individual child.

Have the students make a chart like the one below to record their observations of the different experiments.

Experiment	What Materials Were Used	What Happened	What Caused It to Happen
1. Carrot			
2. Egg			
3. Potato			
4. Liquid			

When they have recorded the information ask them to answer these two questions: What were the similarities? What were the differences?

Suggested Activity No. 1:

Ask the students to write a paragraph in answer to the question: How has man used the information in this unit?

Suggested Activity No. 2:

Have students record the amount of water which has risen in the tubes each day by marking the level of the water in the tubes and measuring the distance it has moved. Does the water in all the experiments rise at the same rate?

PLANTS AND ANIMALS FOR FOOD (Pages 131–156)

Science Concepts:

Hogs, sheep, and cattle are animals commonly used as food for man.

Man uses water animals for food.

Oyster eggs are fertilized by males depositing sperm in the water over the eggs.

Fertilized oyster eggs develop in a few hours.

Oysters live on microscopic water plants.

Starfish and snails are natural enemies of oysters.

All plants are similar.

Food derived from plants may be classified in six groups: fruits, cereals, vegetables, nuts, spices, and beverages.

The pineapple is a fruit.

Pineapple plants must be cultivated to produce fruits.

The stock of a pineapple develops into a fruit.

The mealy bug destroys pineapple plants.

Pineapple plants require more iron than they are able to acquire from the soil.

Wheat is classified by its kernels.

Wheat is planted during two seasons, spring and fall.

The seed is the part of the wheat plant used for food.

Flour is made from wheat.

The inner part of the wheat kernel is called the endosperm.

The endosperm contains the starch and protein.

The outer covering of the wheat is the bran layer.

There are four kinds of flour: hard wheat, soft wheat, whole wheat, and graham.

Yeast plants feed on sugar in producing bread.

Yeast plants give off carbon-dioxide gas.

The material in this unit introduces the student to many different types of communities both foreign and local. It also suggests a type of activity on page 67 of the Companion Book which helps students summarize information about different processes. The interrelationships of living things and how man controls these interrelationships are emphasized throughout this unit.

Suggested Activity No. 1:

It may be possible for the students to visit a butcher shop and have a butcher explain the parts which are referred to on page 62 of the Companion Book.

Suggested Activity No. 2:

On page 63 of the Companion Book they may in addition find a place in the community which represents two different kinds of habitats. They may be compared in a similar manner to the ones in this exercise.

Suggested Activity No. 3:

Students may make block-diagrams of industrial processes in their own communities similar to the ones on pages 67 and 68 of the Companion Book.

Suggested Activity No. 4:

They may also enjoy making reports about other ways of producing the food that we eat.

Suggested Activity No. 5:

Make a display of canned foods the labels of which tell where they were grown or packed. Have students find these places on a world map and indicate with a pin where the food was produced. When this is completed, ask the students to make a chart to summarize the kinds of places where the food was produced, such as ocean and land. Have them classify the foods according to countries and zones of the earth. Read the first paragraph on page 131 and add this information to the map and the chart.

Suggested Activity No. 6:

Ask the students to read the second paragraph on page 131 and list the objectives for this unit. They should be stated as follows:

1. To explain what scientists have discovered about raising plants and animals for food.
2. To explain how man has used power machinery to raise food.

3. To explain how the scientific discoveries have made possible a variety of foods.

Ask them to change the above ideas into problems and to answer them when they have completed the unit.

Suggested Activity No. 7:

List each picture in the unit and write the answer to this question for each: Why was this picture included in this unit?

Suggested Activity No. 8:

Make a list of cereals eaten by the class. Identify the kind of plant from which each is made. Make a chart to summarize the information.

Suggested Activity No. 9:

Write to companies who produce and package foods mentioned in this unit. Ask for descriptive material about their products and the processes by which they are produced. The addresses can be found on the packages.

SCIENTISTS COMBAT DISEASE (Pages 157–171)

Science Concepts:

A virus causes influenza.

Vaccines are solutions made with dead micro-organisms which cause the disease.

Vaccines cause the body to produce antibodies.

Vaccines produce immunization.

A vaccine produced by mixing viruses of distemper and influenza is effective in immunizing ferrets.

Encephalitis is caused by a virus.

Specific toxins and antitoxins produce immunity for specific diseases.

Vaccines have been developed for diseases such as typhoid, pneumonia, whooping cough, and influenza.

Chlorine is used in water to kill micro-organisms.

The main purpose of this unit is to emphasize the great number of agencies, people, and products that are essential to the solution of major health problems. In this age of extensive travel by air, ship, and rail it is important that students realize the health problems which have developed as a result of these scientific inventions. The students may read through the material in the textbook before they begin work on the exercises in the Companion Book. The first exercise in the Companion Book helps associate words and their meanings. The exercise on page 70 shows the relationships of disease to the human body. It is important that students realize that any disease which affects the human body also affects the community and many other people. For this reason the exercise on page 71 follows the exercise which has just been completed. With the information of the effects of these diseases upon communities and individuals, it is important to identify some of the causes of these diseases. The exercise on page 73 continues the development of the skills essential to gathering information from a graph. These same skills may be used to obtain information from graphs that are made about the community. Such information as this may be found: the number of cases of different kinds of diseases, the number of accidents, the number of people hospitalized, or the number of deaths in the community for different age groups. As a preface to the exercise on page 75, a doctor may be invited to speak to the class about epidemics which have occurred in the community. The exercise on page 76 helps students compare the kinds of information that can be recorded by studying different kinds of maps.

Suggested Activity No. 1:

It would be interesting for children to try to make a map of their community which would show the same kind of information that is found on the maps on pages 168, 169, and 171.

Suggested Activity No. 2:

Perhaps they can find someone who has had a cold and trace the people with whom he has come in contact. If they can discover where these people have gone they may be able to make a map similar to the one in the textbook.

Suggested Activity No. 3:

It is interesting also to take as an example one person in a community who has a cold or a sore throat and to list the number of people with whom he has come in contact during different hours in the day. In turn try to discover people with whom these people have made contacts and in this way show how many different individuals may be exposed to one sore throat or one cold.

RADIO BROADCASTING (Pages 172–190)

Science Concepts:

The transmitter is the sending part of the radio.
The receiver is the receiving part of the radio.
The radio microphone is for the purpose of varying an electric current.
The radio transmitter sends radio waves in all directions.
Radio waves travel in straight lines.
Radio waves travel at the same speed as light.
Radiant energy of the sun produces an ionized layer of gas in the atmosphere.
Radio waves are reflected by the ionized layer in the atmosphere.
There are five ionized layers of gas in the atmosphere.
Radio waves can penetrate clouds, fog, smoke, and many other substances.
Large amounts of metal may absorb radio waves.
Electrical appliances such as electric motors may produce radio interference.
Electrical discharges in the atmosphere send out radio waves of many frequencies.
Frequency is the number of waves sent out per second.
Radio stations operate on a designated frequency.
Radio waves become weaker as they travel through space.
Radio stations operate on an assigned watt-power output.
The most important part of the radio is the vacuum tube.
The vacuum tube consists of three main parts: filament, grid, and plate.

The heated filament gives off electrons in a vacuum tube.
The plate collects the electrons in a vacuum tube.
The grid controls the flow of electrons in a vacuum tube.
The grid of a vacuum tube is always negative.
The plate of a vacuum tube is positive.
A very weak current on the grid may cause great changes in plate current.
A receiving set consists of three main parts: detector, amplifier, and speaker.

The unit on radio broadcasting emphasizes the important questions children ask about the radio and the way in which it functions. These are printed in boldface type throughout the unit. It would be wise, perhaps, for the teacher and the students to read this unit together and to list the sentences in their own words which help answer the questions in boldface type. When this has been done and the questions have been answered, the students should be allowed to do the exercises in the Companion Book on pages 78 through 81. They will be able to do these by referring to the material that they have read and discussed. Visits to the radio station and an examination of the different parts of a radio set are helpful to students who have difficulty in visualizing those things which they read about.

Suggested Activity No. 1:

Borrow an old, small radio set and examine it. See how many parts can be identified by the students.

Suggested Activity No. 2:

Ask a radio repairman to discuss the parts the students do not know. Ask him to explain the most common repairs he is asked to do.

Suggested Activity No. 3:

Make a vocabulary drill of the words used to explain the radio.

Suggested Activity No. 4:

Compare the similarities and the differences between the telephone and the radio.

Suggested Activity No. 5:

Write a radio script to explain how a radio functions and how broadcasting is done.

BONES (Pages 191–199)

Science Concepts:

Every adult has about 222 bones.

Variation in the number of bones is likely to be found in wrists, ankles, and the lower end of the vertebral column.

The skeleton is made up of several groups of bones: skull, vertebral column, pelvic bones, ribs, hands, and feet.

At birth the vertebral column is straight.

Through growth and development the vertebral column becomes curved.

The organs of the body are influenced by gravity.

The weight of the body organs is above the pelvis.

Each group of the body organs fits into a curve of the vertebral column.

The vertebral column adjusts to the position in which it is most constantly held.

The human body requires exercise in order to function properly.

The ribs are attached to the sternum with cartilage.

The skull has cavities for the eyes, nose, sinuses, and brain.

Although this unit is short, it is presented in such a way that students have an opportunity to ask questions about their own bodies. The picture on page 192 is particularly helpful in introducing questions of this type. Its purpose is to show changes which occur in the vertebral column. The exercise on page 82 of the Companion Book should serve as an introduction to a discussion of the postures assumed by students in the class. An analysis of the kinds of things that the members of the group as a whole need to do to improve their posture is one way of developing health habits without identifying individuals or embarrassing them by making their difficulties apparent to the whole group.

Suggested Activity No. 1:

Use a chart of the skeleton and ask students to indicate where the other organs of the body are located. They should be able to locate the brain, eyes, ears, lungs, heart, stomach, diaphragm, small and large intestines, liver, pancreas, and appendix.

Suggested Activity No. 2:

Some student may enjoy interviewing a doctor about "sinus trouble" and reporting the information to the class.

Suggested Activity No. 3:

If a shoe store in town has a machine by which one may see the bones in his feet, perhaps the manager would permit the members of the class to observe their feet.

Suggested Activity No. 4:

Ask the physical education director to suggest exercises to improve and maintain good posture.

THE MILK SUPPLY (Pages 200–210)

Science Concepts:

Selective breeding of cows has made possible the production of larger quantities and better qualities of milk.
Milk contains water, protein, fat, sugar, minerals, and vitamins.
Female mammals secrete milk.
Small glands in the female secrete milk.
Micro-organisms contained in milk change the sugar to lactic acid.
Diseased animals and dirty cows, barns, containers, and hands of milkers contaminate milk.
Milk is graded by the number of bacteria per c.c.
Pasteurization uses heat to kill micro-organisms.
The most important dairy products are butter, cheese, and ice cream.
Butter is the fat in the milk.
Cheese is produced by causing a chemical change in the milk.

"The Milk Supply" is a unit which can be summarized by a block-diagram similar to the one which was made for the production of flour on page 67 of the Companion Book. The children should be able to read the material on pages 201 through 210 and to make a block-diagram of this kind. The materials for the exercise on page 86 of the Companion Book should be provided by the teacher. The students should be allowed to do this exercise individually while they are working to develop the block-diagram.

Suggested Activity No. 1:

Write to a dairy which supplies milk for your community. Ask for information about these two questions: What kinds of cows supply the milk you sell? Why are these kinds of cows used instead of other cows?

Suggested Activity No. 2:

If students live on farms, ask them to discuss the qualities of the different breeds of dairy cows.

Suggested Activity No. 3:

Visit a farm or a dairy if possible. Ask the kind of food the cows are fed. Ask the kinds of plants that are poisonous to cows or which flavor the milk so that it is not palatable.

SOIL CONSERVATION (Pages 211–241)

Science Concepts:

There are six divisions of soil: good farm land, poor farm land, arable land, marginal land, mountains, and bad lands.
Much of the land of the United States was once covered by forest and native grass.
Man removed the forest for personal and commercial uses.
Cultivation of soil started erosion.
Wind erosion was extremely serious between 1932 and 1934.
Land ruined by erosion can be made productive.
Wind erosion may be prevented by running furrows crosswise to prevailing winds.

There are three kinds of water erosion: sheet, furrow, and gully.

Erosion may be controlled by contour farming, cover crops, strip cropping, and terracing.

Constant planting of the same crop removes available food materials and produces chemical change in the soil.

Fertility of soil may be maintained by returning part of the plants to the soil or by adding new plant food in the form of chemicals.

The desired amount of moisture in soil may be maintained by draining excess water or by adding water by irrigation.

There are five types of irrigation: furrow, flooding, border, sprinkler, and sub-surface.

The unit on soil conservation has been preceded by the unit on soil in which the basic ideas of the origin and the processes of producing soils were described and learned. The differences which exist among soils and the places where they are found were described in this unit also. The students were asked to describe the soil and its production in their own community. This material is basic to an understanding of the conservation of soil. In addition to soil conservation, forest conservation, erosion, irrigation, and conservation as a national problem are presented in the exercises in this section of the Companion Book on pages 89 through 97.

The unit is written to introduce students to different problems of conservation that exist in different parts of the United States. The unit in the textbook, pages 211 through 241, is generously illustrated with drawings and diagrams. The graph on page 212 and the picture on page 221 are two parts of this unit which most impressed a German scientist to whom this book was sent. In his letter to one of the authors he compared the graph on page 212 with conditions in his country. It was inconceivable to him that so much marginal land should be idle in the United States and that people with as much scientific knowledge as ours would permit conditions to exist, such as are shown in the picture on page 221.

Pages 87–88 of the Companion Book introduce the unit with an exercise about the history of soil in the United States. This

exercise is to be used with the pictures on pages 216 and 217. The discussion of these pictures and the completion of this exercise will form a good introduction to the unit on soil conservation. With the introduction of this unit completed, the students should analyze the material so that they will recognize divisions of the unit. Soil conservation is divided into several sections: the wasting of soils, pages 212 through 221; the prevention of erosion, pages 222 through 230; maintaining the fertility of soil, 231 through 233; maintaining the moisture in the soil (irrigation), 233 through 240.

After the unit has been introduced by a discussion of the pictures and the exercises in the Companion Book, some time can profitably be spent in a discussion of the maps on pages 213 through 215. Each map pictures a different section of the United States and indicates the type of conservation problem that is important in that area. These sections may be referred to in writing the answers to the exercise in the Companion Book.

It would be well to review some of the work in the unit on soils by asking the children to review the kinds of weathering and to identify the picture on page 218 with one of these soil formation processes. In the map on page 219 are indicated some of the natural features of the United States before it was extensively settled.

As the students read and work with the exercises in the Companion Book for each of these sections, certain ideas and attitudes about soil conservation can be developed if the material is related to events in the community. Perhaps the students can find a tree such as the one described on page 89 of the Companion Book. The exercise on pages 90 and 91 relates the activities to the community in which the students live. Students may be able to find examples of changes which have occurred that have made conditions such as the ones pictured on page 92. The exercise on page 93 may be related to their own school. Someone once made the statement that school yards are the greatest evidence for the need of conservation. The material on page 94 emphasizes the long period in man's history that irrigation has been a common problem. Students might explore their own communities to see how many of the fourteen methods for keeping soil from being carried

away, listed on pages 95 and 96, are used in their own communities. The exercise on page 98 may be used as a test exercise.

Suggested Activity No. 1:

Write to the soil conservation office of your community or state. Ask for information on soil conservation. Make a report of the information that is not included in this unit.

Suggested Activity No. 2:

Make a picture, diagram, or chart to show the causes which make soil conservation a problem, the practices which are recommended for soil conservation, and the results of the practices.

Suggested Activity No. 3:

Make a model with soil to show the different types of irrigation discussed in the unit. Write a brief description to explain why each method is used.

THE AUTOMOBILE (Pages 242–274)

Science Concepts:

Gasoline engines use heat to produce power.
Gasoline engines are internal-combustion engines.
Gasoline engines burn a mixture of air and vaporized gasoline.
An electric spark may heat a vaporized mixture of gas to its kindling point.
Gasoline contains carbon and hydrogen.
The combustion of gasoline produces carbon dioxide and water.
Expanding gases cause the piston to move.
Gasoline and air are mixed by a carburetor.
Air pressure causes gasoline to vaporize in the carburetor.
Gasoline and air must be mixed in the right proportions to burn.
The piston is the moving wall of the cylinder.
The connecting rods connect the piston to the crankshaft.

The intake valve allows fuel to enter the cylinder.
The exhaust valve allows burned gases to leave the cylinder.
The flywheel causes the piston to continue to move.
The automobile engine is a four-stroke cycle.
A spark plug produces the spark to ignite fuel.
An induction coil changes low-voltage electricity to high-voltage electricity.
Only one cylinder is ignited in a gasoline engine at any one time.
The accelerator operates the throttle which controls the amount of mixture entering the cylinders.
An electric motor is used to start the engine.
Each cylinder is surrounded with a water jacket to dissipate the excess heat.
The automobile engine is separated from the driving parts by a clutch.
Two kinds of clutches are disc clutch and liquid clutch.
The power developed by the engine varies according to the speed of the engine.
The transmission box enables the automobile to develop much power at low speed.
The drive shaft delivers the power from the transmission to the rear wheels.
The differential allows the rear wheels to turn at different speeds.
Brakes stop a car by producing friction.
Friction is produced by brake shoes being forced against brake drums.
Gears are used in the steering mechanism to provide greater control of the car.

Students in the eighth grade will soon be driving cars and applying for drivers' licenses. Many of the questions which children ask each day are related to the automobile. The modern science student is not only interested in using these devices; he is interested in learning how they operate and why they operate. The exercises in the Companion Book and the material in the textbook have been written so that students may use the two of them to-

gether in learning to understand the operation of an automobile. As many additional pictures, diagrams, charts and pamphlets as a teacher can assemble to help students with the material in this unit will be of benefit to them. Many of the large automobile companies produce series of pamphlets for school use which are available upon request. Students should be able to work by themselves in studying the textbook and in completing the exercises on this unit. The teacher can be of most service as he helps individual students and bases his lesson upon the common difficulties which the group finds need explanation and discussion.

Suggested Activity No. 1:

Open the hood of an automobile. Ask students to explain as many of the parts as they can see. Compare the engines of different cars.

Suggested Activity No. 2:

Visit a garage to identify the parts of a car. Ask a repairman to explain the kinds of repairs the various parts often require.

Suggested Activity No. 3:

Explain what happens to a drop of gasoline from the time it enters the gas tank to the time it is used.

Suggested Activity No. 4:

Explain the diagrams in the book by asking various students to represent different parts. Have them explain what they do.

MY HEALTH AUTOBIOGRAPHY

Several exercises are included in the Companion Book which are of importance to individual students. The exercises on pages 111 through 117 represent material of this kind. Each of these exercises is designed to help a student analyze his health habits. The culmination of the exercise is a health autobiography which is written by the student. These may be examined at this time or earlier in the year and when they are completed the teacher should

read each one carefully and counsel the students about their health problems. If there is a school nurse, these autobiographies may be used as information for her. Many times there will be revealed problems which should be brought to the attention of parents. A science teacher may be of real service to his students if he finds it possible to provide the time to discuss and talk about personal problems. These exercises have been designed to provide introduction and evidence for conferences of this kind.

FISH, TURTLES AND CRABS

It is interesting for science students to deal with many things that are not included in a regular textbook. The exercises on pages 118 through 124 of the Companion Book are designed for this purpose. The students are urged to discover main characteristics of these animals, to be aware of scientific names and common names, and to discover how scientists have classified living organisms. These may be assigned as homework or they may be used as exercises upon which students may work when they have completed other units upon which they are working.

WITHIN THAT SHELL (Pages 320–332)

Science Concepts:

Some chicken eggs are fertile and some are infertile.
Male sperm cells of the rooster unite with egg cells of the hen.
The incubation period of fertile eggs is about 21 days.
When chicks are hatched they have enough food stored in their bodies to last approximately two days.
Germ spots may develop embryos.
Chick embryos must be kept warm to hatch.
Live embryos are developing animals.
Bacteria may make eggs spoil.
The food eaten by hens may determine the color of the yolk.
A female chick has germ tissue which produces eggs.
Female germ tissue is called an ovary.
When the egg cell is grown it is released by the ovary into the oviduct.

The oviduct secretes lime which forms the eggshell.
Several days are required to produce an egg.

This is a unit which again emphasizes the ideas that are important in connection with foods that we eat and the health of individuals. The exercise on page 127 in the Companion Book is designed to help students further develop the reading skills needed for the selection of specific information from reading material which helps answer specific questions. Some students like to obtain fertile eggs and incubate them in the classroom so that they can watch the development of the chicken. A chart similar to the one made on page 11 of the Companion Book could be drawn to show the life span of a chicken. The teacher may bring in examples of different sizes of eggs and eggs in which it is possible to show the quality and the grade specifications. Students are often interested in figuring whether it is cheaper to buy eggs by the dozen or by the pound.

The teacher should read and discuss this unit with the children. Questions should be encouraged about the processes explained in the unit so that they are clear to the students. This process may be discussed in relation to other animals also. The exercise on page 128 of the Companion Book may be used as a summary.

Suggested Activity No. 1:

Make a collection of as many different eggs of animals and seeds of plants as can be found. Write what is similar and what is different about each group.

Suggested Activity No. 2:

Make a list of all the pictures of things in this book that are the result of reproductive processes of animals or plants.

Suggested Activity No. 3:

Cut a hard-boiled egg and identify the parts. Explain where each came from and the materials used to produce each part that is described in the unit.

Suggested Activity No. 4:

Interview the postmaster concerning regulations about sending eggs and chickens through the mail.

Suggested Activity No. 5:

Collect pictures of as many different kinds of eggs as possible and the animals that produced them. Make a chart to show where the eggs are kept before they hatch, and the size of egg in relation to the size of the animal.

THE HEART AND THE BLOOD (Pages 333–341)

Science Concept:

The heart forces the blood through the blood vessels.
The heart rests between beats.
Carbonic acid stimulates heart muscular action.
Carbonic acid is produced when carbon dioxide dissolves in water.
The beating of the heart involves a cycle of activities.
The right side of the heart is separated from the left side.
The veins lead into the auricles of the heart.
The pulmonary system takes blood to and from the lungs.
The blood leaves the heart from the ventricles.
The pulse is caused by circulating blood.
An individual's activities influence his pulse rate.
The blood and lymphatic systems absorb water and food from the intestines.
The blood contains blood cells, and lymph contains lymph cells.
Red blood cells are made in the marrow of the bone.
A red blood cell does not have a nucleus when it enters the blood stream.
Red blood cells cannot reproduce.
Red blood cells contain a pigment, hemoglobin.
Hemoglobin combines chemically with oxygen to form oxyhemoglobin.

White blood cells are made in the marrow of the bone and in lymph glands.

White blood cells remove undesirable materials from the body.

White blood cells attack micro-organisms.

A good introduction to this unit is the exercise on page 130 of the Companion Book. The teacher may demonstrate the beef heart or each student may obtain a heart for himself and do the exercise. It continues through page 132. When the exercise has been completed the pupils should refer to the material in the textbook to verify their observations. The diagram on page 336 will be very helpful. The exercise on page 132 of the Companion Book should be done after the material on pages 337 and 338 has been read. This is also true of the exercises on pages 133 and 134.

Suggested Activity No. 1:

Ask the students to state which they believe the more muscular and why—the walls of the auricles or the ventricles.

Suggested Activity No. 2:

Make a chart to show the path of the blood through the body.

Suggested Activity No. 3:

By a chart compare the functioning of the heart with the functioning of an internal-combustion engine. What are the main differences?

Suggested Activity No. 4:

Answer the question: Why are valves essential in the heart?

Suggested Activity No. 5:

Make a diagram to show the following information:

1. One and one-half seconds are required for a drop of blood to move through the heart.
2. Five seconds are required for a drop of blood to move through the pulmonary system.

3. Eight seconds are required for a drop of blood to move from the heart to the brain and back again.
4. Eighteen seconds are required for a drop of blood to move from the heart to the foot and back again.

OUR WATER SUPPLY (Pages 342–364)

Science Concepts:

The word gravity means weight.
Rain and snow fall to the earth because of gravity.
The force of gravity is always the same.
The force of gravity decreases as the distance from the earth's center increases.
Water pressure increases with depth.
Atmospheric pressure may affect water.
Gravity and atmospheric pressure make it possible to pump water.
Liquids transmit pressure in all directions.
Liquids cannot be compressed.
The pressure of gas increases when the volume is decreased.
The pressure of gas decreases when the volume increases.
The attraction of the earth for water molecules produces pressure.
Water may transport micro-organisms.
Undesirable substances mixed with water are called impurities.
Purification is the process of removing impurities from water.
Water is purified by settling basins, filter beds, and chemicals.
Hard water contains mineral compounds.
Soft water is free from mineral compounds.
Mineral compounds may be removed by heating or by chemical processes.

Both students and teacher have probably recognized that the science material in the How and Why Science Books is constantly applied to real people and real situations in which it can be used to analyze, explain, or predict the causes or the effects of events.

The story which introduces the unit on page 342 is an example of a true experience in which water played a major part. It would be well for the students in studying this unit to change the topics that are in boldface type into questions. For example, on page 344 the topic, "Water Is Affected by Gravity," could be changed into this problem: "How is water affected by gravity?" When the students have read the material in that section of the unit, they should be able to answer this question. This same procedure can be used for each one of the topics in this unit. Many of the exercises in the Companion Book are written to provide spaces in which to answer these questions. Experiments and the demonstrations should be done at the time indicated in the directions.

Suggested Activity No. 1:

List the things in the pictures on pages 342 and 343 that are affected by gravity. Explain the effect.

Suggested Activity No. 2:

Answer the question: Why does gravity cause air to exert pressure?

Suggested Activity No. 3:

List as many examples as possible of how the world would be different if air did not exert pressure.

Suggested Activity No. 4:

Examine a house in the process of construction. Make a diagram to show the arrangement of the pipes for water.

Suggested Activity No. 5:

Make a model similar to the one on page 360 and explain the purpose of the process. Examine a drop of the water under a microscope before and after it moves through each part.

Suggested Activity No. 6:

Make a diagram to show the source of the water for your community and the way in which the water is transported to the homes.

Science Concepts:

Balloons float because they are lighter than air.
Airplanes are heavier than air.
An airfoil is a surface designed to produce useful force.
Molecules of gas are in constant motion.
Molecules striking solid surfaces produce pressure.
The density of air increases as the pressure increases.
There is a difference in pressure on the upper and lower sides of the airfoil.
Warm air is less dense.
The thrusting effect of an airplane is produced by the propeller.
Air friction produces drag on an airplane.
Polishing airplane metal reduces drag.
Airplane motors are made differently than automobile engines.
Airplane engines require pumps to force the oil through the engine.
Airplane engines may be radial or in-line.
Superchargers increase the intake of oxygen.
Airplanes in flight are controlled by stabilizers, elevators, and rudders.
Ailerons aid in turning airplanes.
Tabs prevent side slip.
Air-speed indicators tell the speed of the airplane compared to speed of air.
The magnetic compass tells the direction the plane is traveling.
The altimeter is operated by air pressure and indicates the height.
The turn-and-bank indicator indicates the direction and angle the plane is moving from true position.
Robot pilots operate on the principle of the gyroscope.
Airplanes may be divided into three main classes: commercial, military, private.
Monoplanes have one wing.

Biplanes have two wings.
Airplane wheels are called landing gears.
Seaplanes land on water.
Amphibious planes are equipped to alight on either land or water.
Helicopter wings rotate to produce lift.
Autogiros have small fixed wings.

It would be well for the teacher and the students to work through this unit together. The teacher should plan carefully so that the exercises in the Companion Book are done at the time which will work best for the members of the class. On pages 142 through 155 there are many exercises, experiments, and demonstrations which the teacher and the students can do together and which will provide the basis for a great deal of discussion and explanation as they work together. Page 156 provides a review of the important vocabulary of the last few units. The final activity for the science class should be the reading of the summaries on page 4 of the Companion Book. It would perhaps be interesting to invite parents or one other grade to a program called "The Review of Science." At the end of the program the teacher should stress the idea that HOW AND WHY CONCLUSIONS in science has constantly emphasized that man's living has been improved as he has applied scientific information to the solution of his problems, that science in the world today will continue to be of current interest to all people for it affects many of the daily activities which they perform. Reading and thinking and studying in the field of science can continue if one has learned the science and carefully developed the skills which have been taught throughout this series of science books and the accompanying Companion Books.

Suggested Activity No. 1:

Have students bring model planes to class and describe their parts and their functions.

Suggested Activity No. 2:

Explain why each of the means of transportation in the picture on page 365 is able to stay in the air.

Suggested Activity No. 3:

Imagine that you are a pilot. Describe what you would do as you operated an airplane.

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The good science teacher provides at least one magazine for his science students, if such magazines are not available in a school library. Some teachers prefer to subscribe to different ones different years. The best way to decide which magazine is most useful to yourself and your students is to order one copy of several and examine each one before placing the order for the year.

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SOURCES OF BIOLOGICAL APPARATUS AND SUPPLIES

Audubon: National Audubon Society, 1974 Broadway, New York City.

Bausch and Lomb Optical Co., Rochester, New York.

Biological Supply Company, 1176 Mount Hope Ave., Rochester, New York.

Breeding and Laboratory Institute, 567 Third Avenue, New York City.

Central Scientific Company, 460 East Ohio Street, Chicago, Illinois.

Chicago Apparatus Company, 1735–1743 North Ashland Ave., Chicago, Illinois.

Clay-Adams Company, 117–119 East 24th Street, New York City.

Denoyer-Geppert Company, 5235 Ravenwood Avenue, Chicago, Illinois.

Fisher Scientific Company 709–717 Forbes Street, Pittsburgh, Pa.

General Biological Supply House, 761–763 E. 69th Place, Chicago, Illinois.

Marine Biological Supply Company, 329–331 Second Street, Ann Arbor, Michigan.

McKnight and McKnight Supply Company, 123 North Street, Normal, Illinois.

Spencer Lens Company, Buffalo, New York; 45 Second Street, San Francisco, California; 33 West 42nd St., New York, New York.

Standard Scientific Supply Corporation, 34–38 West 4th Street, New York, N. Y.

Ward: Charles H. Ward, Inc., 5–7 Prospect Street, Rochester, New York.

Welch: W. M. Welch Scientific Company, 460 East Ohio St., Chicago, Illinois.

Zeiss: Carl Zeiss, Inc., 728 South Hill St., Los Angeles, California.

SOURCES OF BULLETINS AND PAMPHLETS

American Child Health Association, 450 Seventh Ave., New York City.

American Forestry Association, 1727 K. St., N. W., Washington, D. C.

American Medical Association, 535 Dearborn Street, Chicago, Illinois.

American Museum of Natural History, Columbus Ave. and 77th St., New York City.

American Nature Association, 1214—16th St., N. W., Washington, D. C.

American Public Health Association, 450—7th Ave., New York.

American Red Cross, Washington, D. C.
American Tree Association, 1214 Sixteenth St., N. W. Washington, D. C.
Bauer and Black, 2500 South Dearborn St., Chicago, Illinois.
Borden: The Borden Company, 350 Madison Ave., New York City.
California Fruit Growers Exchange, Box 530 Station C., Los Angeles, California.
California and Hawaiian Sugar Refining Corporation, Ltd., 215 Market St., San Francisco, California.
Chicago Apparatus Company, 1735 North Ashland Ave., Chicago, Illinois.
Columbia: Bureau of Publications, Teachers College, Columbia University, New York City.
Eastman Kodak Company, 255 State St., Rochester, New York.
Field Museum of Natural History, Grant Park, Chicago, Illinois.
General Biological Supply House, 761–763 East 69th Place, Chicago, Illinois.
General Electric Company, Department 166, Nela Park, Cleveland, Ohio.
General Foods Corporation, Battle Creek, Michigan.
Government Printing Office, Superintendent of Documents, Washington, D. C.
Heinz: H. J. Heinz Company, 1062 Main St., Pittsburgh, Pennsylvania.
Hershey Chocolate Company, Hershey, Pennsylvania.
International Harvester Company, 606 South Michigan Ave., Chicago, Illinois.
Johnson and Johnson, New Brunswick, New Jersey.
Metropolitan Life Insurance Company, One Madison Square, New York City or 600 Stockston St., San Francisco, California.
National Dairy Council, 910 South Michigan Ave., Chicago, Illinois.
National Park Service, Washington, D. C.
Pillsbury Flour Mills, Minneapolis, Minnesota.
Silk Association of America, 468 Fourth Ave., New York City.
Standard Oil Company of California, Standard Oil Building, San Francisco, California.

State Department of Agriculture. (Bulletins issued for each state.)

State Fish and Game Commissions. (Bulletins issued for each state.)

United States Bureau of Fisheries, Washington, D. C.

United States Department of Agriculture, Office of Information, Washington, D. C.

United States Department of Public Health, Washington, D. C.

Ward's Natural Science Bulletin, Box 24, Beechwood Station, Rochester, N. Y.

SOURCES OF LANTERN SLIDES

American Museum of Natural History, 77th St. and Central Park West, New York City.

Audubon: National Association of Audubon Societies, 1974 Broadway, New York City.

Chicago Apparatus Company, 1735–1743 North Ashland Ave., Chicago, Illinois.

Conrad Slide and Projection Company, 510 Twenty-Second Ave., East, Superior, Wisconsin.

Denoyer-Geppert Company, 5235–5257 Ravenwood Ave., Chicago, Illinois.

General Biological Supply Company, 761 East 69th Place, Chicago, Illinois.

Keystone View Company, Meadville, Pennsylvania.

New York Biological Supply Company, 34 Union Square, New York City.

Welch: W. M. Welch Scientific Company, 1516 Orleans St., Chicago, Illinois.

SOURCES OF MOTION PICTURES

Akin and Bagshaw Company, Inc., 1425 Williams Street, Denver, Colorado.

American Social Hygiene Association, 370 Fifth Ave., New York City.

Bray Productions, Inc., 729 Seventh Ave., New York City.

Eastman Teaching Films, 355 State Street, Rochester, New York.

Educational: The Educational Screen, Inc., 64 East Lake Street, Chicago, Illinois.

General Electric Company, 1 River Road, Schenectady, New York.

Metropolitan Life Insurance Company, 1 Madison Square, New York City.

Society for Visual Education, Inc., 327 So. LaSalle St., Chicago, Illinois.

SOURCES OF PROJECTION EQUIPMENT

Ampro Corporation, 6058 Sunset Blvd., Hollywood, California.

Bausch and Lomb Optical Company, 635 St. Paul St., Rochester, New York.

Bell and Howell Company, 710 North La Brea Ave., Hollywood, California.

Eastman Kodak Company, 355 State St., Rochester, New York.

Holmes Projector Company, 1811 Orchard St., Chicago, Illinois.

Spencer Lens Company, 45 Second St., San Francisco, California.

Western Electric, Electrical Research Products Company, 250 West 57th St., New York City.

SOURCES OF STILL PICTURES AND CHARTS

American Child Health Association, 450 Seventh Ave., New York City.

American Forestry Association, 380 Jelliff Ave., Newark, New Jersey.

American Museum of Natural History, 77th St. and Central Park West, New York City.

American Public Health Association, 450 Fifth Ave., New York City.

American Red Cross, Washington, D. C.

Armour and Company, Chicago, Illinois.

Audubon: National Association of Audubon Societies, 1974 Broadway, New York City.

Church, Dwight & Company, 27 Cedar St., New York City.

Keystone View Company, Meadville, Pennsylvania.

Metropolitan Life Insurance Co., One Madison Ave., New York City.

National Fire Protection Association, 40 Central St., Boston, Mass.

National Geographic Society, Sixteenth and M. Streets Northwest, Washington, D. C.

National Lumber Manufacturers Association, Washington, D. C.

New York Zoological Society, Bronx Park, New York City.

Nystrom: A. J. Nystrom & Company, 2249 Calument Ave., Chicago, Illinois.

Perry Pictures Company, Box 4, Malden, Mass.

Rand, McNally & Company, Chicago, Illinois.

Science Service, 21st and B Sts., Washington, D. C.

United States Public Health Service, Washington, D. C.

A KEY TO THE COMPANION BOOK

pp. 1–3—*Science in the World Today*

Individual answers.

p. 4—*A Summary*

Individual answers.

p. 5—*Some Things in the World*

1. *a.* Circle: 1, 2, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28.
   b. Mark an A before: 2, 15, 18, 24, 25, 27.
   c. Mark a P before: 3, 11, 12, 16, 19.
   d. Mark an E before: 1.
   e. Mark a Q before: 17, 22.
   f. Mark an O before: 21, 26.
   g. Mark a W before: 6, 9, 10, 20.
2. Individual answers.

p. 6—*Some Things in the World* (continued)

1. prehistoric plants
2. dinosaur
3. dinosaur egg
4. tadpole
5. bur reed
6. pickerel weed
7. frog
8. log
9. pillar
10. baby
11. water
12. cloud
13. atmosphere
14. aster
15. aster seeds
16. prism
17. dragon fly
18. insect nymph
19. insect eggs
20. leaf
21. spectrum
22. chalcedony
23. flint
24. amethyst
25. malachite

p. 7—*Some Things in the World* (continued)

Obvious.

p. 8—*Where Did They Come From?*

1. No answer.
2. pp. 23–25, 28. In rock, in streams, in old stream or glacier beds, near the surface of the ground, in veins, in the rock below the level land.
3. p. 21. During changes in the earth's crust, great heat melted rocks. Many of the chemical elements combined to form compounds. As the molten mass cooled, like elements moved together to form minerals whose crystals have definite patterns.
4. p. 357. The atmosphere.
5. p. 20. The thin outer crust of the earth.

p. 9—*Things Containing Protoplasm*

1. *These Did or Do Contain Protoplasm:*

   a. prehistoric plants
   b. dinosaur
   c. dinosaur egg
   d. tadpole
   e. bur reed
   f. pickerel weed
   g. frog
   h. log
   i. baby
   j. aster
   k. aster seeds
   l. dragon fly
   m. insect nymphs
   n. insect eggs
   o. leaf

   These Never Contained Protoplasm:

   a. pillar
   b. water
   c. cloud
   d. atmosphere
   e. prism
   f. spectrum
   g. chalcedony
   h. flint
   i. amethyst
   j. malachite
2. Scientists have discovered that life exists in a certain substance, protoplasm, that is found in all living plants and animals.

3. Things containing protoplasm: Circle all the letters.
   Things never containing protoplasm: Circle all the letters.
4. *a.* protoplasm or cytoplasm near surface of cell
   b. protoplasm or cytoplasm under the ectoplasm
   c. something inside the nucleus
   d. protoplasm outside the nucleus
   e. a membrane around the nucleus
   f. a body in the cell

p. 10—*How a Person Changes*

1. *a.* one
   b. two
   c. eight
   d. forty-one
   e. four

2–5. Individual answers.

6. For the first twenty-five years, the body grows. For the next twenty-five years there is no growth. After age fifty, the body cells die faster than they are produced.

Inherited Characteristics

Individual answers.

p. 12—*Protozoans and Children*

1. Elements in protoplasm: oxygen, 65%; carbon, 18.5%; hydrogen, 11.0%; nitrogen, 2.5%.
   Similar: Each contains protoplasm. Each contains similar elements, water, and solid materials. Each is alive and can make new protoplasm.
   Different: A child is more complicated. He has more parts, can do more things, is specialized, has parents, lives in many different places, etc.
2. Ways similar: They have the same organs; can do similar things such as hear, eat, etc.; each is growing; each has parents; each has the same number of bones in the skull; each is made of protoplasm.
   Ways different: The baby's organs are not so well developed; the fourteen-year-old can do everything better; each is a different age; their skulls, shape of head, kind of food, interests, ability to focus eyes are different.

p. 13—*Properties of Metals*

1. *a.* Most metals are solids, but they can be melted.
   b. Metals are shiny when cut, filed, or scraped.
   c. They can be pounded into various shapes.
   d. Most metals are heavier than substances that are not metals.
2. *a.* ocean
   b. pure
   c. chemical compounds
   d. substances
3. Write *a* before *a*.
   a before *b*.
   c before *c*.
   b before *d*.
   a before *e*.

p. 14—*Increasing Your Science Vocabulary*

1. Water-borne.
2. Recovery of gold from alluvial material.
3. Washing material down a hill and through a sluice box by a powerful stream of water.
4. Metals or compounds of metals.
5. Factories to remove metals from ores.
6. Shaft extending upward from the main tunnel.
7. Getting ore out through short opening in the top of the tunnel.
8. Space above the tunnel.
9. Process of measuring land.
10. Small copper tube closed at one end.
11. Pile of waste rock.
12. Machine to break rock.
13. Removing metal compounds from rock.
14. Rock particles containing a little of metal compounds.
15. Separation of minerals from worthless rock.
16. Material left when the oil is removed.

Identifying Reading Signals

1. *a.* 1.
   b. 5, 9, 11, 12.
   c. 10.
   d. 2, 3, 4, 6, 7, 8, 13, 16.

2. Raise—to lift up.
   Dump—waste heap.
   Concentration—the fixing of attention on one thing.

p. 15—*Where Are Minerals and Metals Found?*

1. mountains
2. Color the south polar region red.
3. Individual answers.

p. 16—*Where Are Minerals and Metals Found?* (continued)

4. Individual drawings. See p. 20 of How and Why Conclusions.
5. *a.* The earth's crust, in which mineral resources are found, shifted so that the mountains and oceans were formed.
   b. During the shifting, heat and pressure melted the rock whose chemical elements combined with others like themselves to form minerals.
   c. Some metals melted and were forced into crevices in rocks.
   d. Some metals combined with other substances and formed large beds or deposits.
   e. Some metal compounds were dissolved in the earth and carried by the water into rock where the compounds formed veins.

p. 17—*Chemical and Physical Changes*

1.

Material	*Physical Change*	*Chemical Change*
Iron	Molten iron flows to bottom of furnace.	Carbon monoxide takes away oxygen from the iron oxide of the ore.
Steel	Iron is heated.	Carbon combines with some of the iron.
Copper	A plate of pure copper out of solution.	The copper sulfate solution takes pure copper from the impure copper ingot.

Brass	Faucets are molded from brass.	Brass is an alloy of copper and zinc.
Bronze	Bronze is molded into statues.	Bronze is an alloy of copper and tin.
Aluminum	Aluminum compounds are melted.	An electric current is passed through the liquid and the aluminum separates from it.

2. They remain the same material, but have changed size, shape, or temperature.
3. The materials have changed and are different materials.

p. 18—*Electroplating*

1. Individual drawings.
2. *a.* The one connected to the negative terminal of the battery.
   b. From the copper connected to the positive terminal and the solution.
   c. Electric current was moving through the solution.
   d. The electric current produces chemical changes which caused the copper to move from one piece to another.

p. 19—*Modern Safety Practices*

1–5. Individual answers.

p. 20—*How Diseases Are Spread*

1. *a.* wind on a dirty street
   b. open garbage can
   c. sneezing without covering nose and mouth
   d. borrowing a powder puff
2. Individual drawings and answers.

p. 21—*How Organisms Spread*

1–2. Individual answers.
3. The mold spread from the infected oranges.
4. Mold grows better in darkness than in light.

Preserving with Salt

1. The potato in the salt water is preserved.
   The potato in the plain water has rotted.
2. It prevents the growth of micro-organisms.
3. The potato in the salt water has not spoiled; there is no evidence of bacteria or fungus. The potato in the plain water shows evidence of bacteria and fungus growth.

p. 22—*Meat and Insects*

1. The piece in the air is spoiling faster, its color is different, its odor is different, its texture is different.

2–3. Individual answers.

4. Individual drawings.
5. a fly
6. The fly laid eggs in the meat.
7. Before the meat was put into the closed container, spoiling had already begun.
8. Cold preserves food and it took longer for the meat to thaw and to start to spoil.

p. 23—*Helping to Control a Disease*

1. *a.* The cooperation of everyone is needed if epidemics are to be controlled.
   b. The health of individuals is influenced by how well they protect themselves from disease.
   c. To control micro-organisms it is necessary to slow down or stop their reproduction.
   d. Micro-organisms are found almost everywhere.
   e. It is possible to wash micro-organisms from the body.
   f. Micro-organisms are transported.
2. Flies: Swat them; destroy their breeding places; use a spray such as DDT; use flypaper.
   Mosquitoes: Swat them; pour oil on breeding places; use a spray such as DDT.

p. 24—*Micro-organisms in the Body*

In the picture the nurse is probably giving the boy a shot of antitoxin. The antitoxin will kill the micro-organisms in

the body so that they can no longer produce toxins which may cause disease.

Keeping a Family Well When One Member Is Sick

Individual answers.

p. 25—*Scientific Attitudes Toward Disease*

Place a check mark before 3, 4, 5, 7, 8, 9.

p. 26—*Experiments with the Telephone*

1. *a.* Individual drawings.
   b. When the pressure on the diaphragm is varied, the closeness of the carbon grains is varied, and the current is varied.
2. *a.* Individual drawings.
   b. More electricity is needed.
3. See p. 74 of HOW AND WHY CONCLUSIONS.

p. 27—*Varying an Electric Current*

1. *a.* Nothing.
   b. The light bulb glows.
   c. The light changes from bright to dim.
2. Individual drawings.
   a. The circuit is broken.
   b. The circuit is broken.
   c. The circuit is made by salt in water.
3. The amount of chemical reaction which takes place determines amount of current.
4. Individual answers (oral).

p. 28—*The Telephone and Electricity*

1. An arrow pointing to the coil of wire in the center of the diagram should be numbered 2.

p. 29—*The Telephone and Electricity* (continued)

2. Arrows to the coil of wire should be numbered 2 and 5. Arrows to the center area should be numbered 3 and 4.

The electro-magnet should be numbered 1.
The cord at the right should be numbered 6.

3. *a–e.* receiver
   f. pressure of diaphragm

p. 30—*Parts of the Telephone*

1–4. Individual answers.

p. 31—*Science Vocabulary*

1. protoplasm: A substance found in all living plants and animals.
2. sutures: The places where the skull bones join each other.
3. metal: A class of materials which has certain properties that are different from those of other materials.
4. rust: A reddish compound formed by the combination of iron and oxygen.
5. veins: Metal compounds found in large cracks in rock.
6. alluvial: Water-borne.
7. pigs: Molds into which iron is poured.
8. alloy: A substance formed by the union of two or more metals or by the union of a metal and a non-metal.
9. magnalium: An alloy—aluminum combined with magnesium.
10. duralumin: An alloy—aluminum, copper, manganese, and magnesium.
11. protozoa: The simplest kinds of animals.
12. virus: A type of protein molecule.
13. toxin: A poison which causes disease in the body.
14. tele: A Greek word meaning *far*.
15. phone: A Greek word meaning *to speak*.
16. galvanometer: An electrical meter which shows small changes in electric current.
17. mouthpiece: The part of the telephone into which one speaks.
18. diaphragm: A thin disc of metal inside the transmitter.
19. clapper: A piece of iron in the telephone bell which has a small rod attached to it with a metal ball on the end.

20. slug: Similar in size and shape to a nickel and used in pay telephones.

p. 32—*Principles of Food Preservation*

1.

Precaution	*Reason*
a. Inside handle on door.	*a.* People must be able to get out quickly.
b. Lights.	*b.* They must be able to find the door, and complete their work quickly.
c. Coats and gloves.	*c.* Coats and gloves prevent extreme chilling of the body.

2. Cold prevents micro-organisms from growing or destroys them altogether.
3. Food spoils because the paper prevents the ice box from getting as cold. The ice lasts longer because the paper insulates the ice from the heat of the food and the air.
4. Individual answers.

p. 33—*Principles of Food Preservation* (continued)

5. The ice cube wrapped in the greatest number of thicknesses of paper lost the least weight. (Any similar answer is correct.)
6. 1—Food cannot be frozen by machine unless it enters the machine.
   2—Food must be separated so each piece will be frozen uniformly.
   3—Food must come in contact with cold.
   4—Food is frozen to preserve it.
   5—Food must leave the machine.
   6—It must be packed for distribution.
7. Drying: Dehydrate food; dry food in sun.
   Heating: Can food.
   Freezing: Quick-freeze food.
   Chilling: Store in spring houses, wells, ice boxes.
   Salting: Use salt.

p. 34—*Two Ways of Freezing Food*

1–4. Individual answers.

5. *a.* The cells remain intact; the flavor and juice are "sealed in."
   b. They do not lower the temperature of foods rapidly enough.
   c. Foods may start to spoil before the cold freezes them.
6. Same as experiment already done, but line the box with ice and salt. Compare results of the two experiments.

p. 35—*Why Do Animals Behave As They Do?*

1–4. Individual answers.

p. 36—*Why Do Animals Behave As They Do?* (continued)

A. 1. It is eating.
   2. Obvious.
   3. *a.* no *b.* no *c.* no *d.* no *e.* no *f.* no
   4. no
   5. *a.* food
      b. take the food into its body
      c. protoplasm
   6. protoplasm

p. 37—*Why Do Animals Behave As They Do?* (continued)

B. 1. Circle: nerve mass, nerve, nerve ring.
   2. Underline: food enters here, esophagus.
   3. Draw lines through protoplasm, nucleus.
   4. *a.* no *b.* no *c.* no *d.* yes *e.* no *f.* no
   5. yes
   6. *a.* (1) esophagus (2) muscles
      b. esophagus
      c. It couldn't take in food.
      d. It can move better. It has muscles and nerves.
      e. food
      f. taking in the food
   7. nervous system.

p. 38—*Why Do Animals Behave As They Do?* (continued)

C. 1. *a.* brain *b.* eye *c.* nerves

2. *a.* yes *b.* no *c.* no *d.* yes *e.* no *f.* yes

3. *a.* yes
   b. light . . . light
   c. two
   d. ten
   e. many
   f. in each cell

4. It has a nervous system which is specialized to receive different stimuli.

p. 39—*Why Do Animals Behave As They Do?* (continued)

D. 1. *a.* brain
   b. sensory cell body
   c. tactile nerves
   d. motor nerve fiber
   e. ventral nerves
   f. ganglion
   g. motor cell body
   h. sensory nerve fiber
   i. ventral ganglion

2. *a.* no *b.* no *c.* no *d.* yes *e.* no *f.* yes

3. *a.* skin
   b. skin
   c. motor neuron
   d. muscle
   e. sensory neuron
   f. an outside influence

4. Write S before *c, d, e, f.*
   Write D before *a, b.*

p. 40—*Why Do Animals Behave As They Do?* (continued)

1. *a.* yes *b.* yes *c.* yes *d.* yes *e.* yes *f.* yes
2. Similar parts: cerebrum, cerebellum, spinal cord
   Different parts: pituitary body in man

p. 41—*A Summary*

1. Amoeba proteus: all blanks.
   Diplodinium ecaudatum: check *feel.*
   Planaria polychroa: check *see, feel, think.*
   Earthworm: check *feel, think.*
   Fish: check *see, smell, hear, feel, taste, think.*
   Man: check *see, smell, hear, feel, taste, think.*

2. *a.* They have different kinds of nervous systems which enable them to respond to different stimuli.
   b. They do not have the same kind of nervous systems and therefore cannot respond to the same stimuli.
   c. They have specialized parts for seeing, smelling, hearing, feeling, tasting, and thinking.
   d. They all respond to some of the same stimuli.
3. Individual answers.

p. 42—*Science Vocabulary*

1. dehydrate: To remove moisture from foods.
2. neuron: A specialized cell which performs only certain functions. It has a cell body, an axon, and a dendrite.
3. axons: One kind of projection from a neuron.
4. dendrites: Another kind of projection from a neuron.
5. sensory neuron: A neuron which receives stimuli.
6. motor neuron: A neuron which causes the body to do things.
7. spinal cord: Located in the center of the vertebral column and composed of many nerve cell bodies.
8. vertebral column: The backbone, inside of which is the spinal cord.
9. white matter: The white covering of the axons and dendrites outside the H formation in the spinal cord.
10. cortex: The outer part of the cerebrum.
11. pinna: The part of the ear which projects from the head and is made of cartilage covered with skin.
12. Eustachian tube: The tube which connects the middle ear with the throat.
13. cones: Nerve cells in the retina which are connected directly with nerve cells of the optic nerve.
14. rods: Nerve cells in the retina not located in the center.
15. visual purple: A special pigment in the rod cells.
16. kaolin: Particles of feldspar which have changed chemically; clay.
17. loam: A mixture of clay and sand.
18. organic matter: All the living things and the remains of living things in the soil.

19. osmosis: The entrance of water through a membrane.
20. cilia: Hairlike parts of its body which help an oyster larva to swim.

p. 43—*Agents of Soil Production*

1. *a.* water *e.* freezing water *i.* waves
   b. volcanoes *f.* temperature *j.* ice sheets
   c. sun *g.* rivers *k.* wind
   d. root growth *h.* mountain streams *l.* chemicals
2. 1—mountain stream; 2—volcano; 3—temperature
   4—ice sheet; 5—wind.
3. Write PPW above 3.
   Write SPW above 1, 4, 5.

pp. 44–45—*Soil Makers*

Individual answers.

p. 46—*Bacteria in the Soil*

II. 1. Check: *a, c, d.*
    2. Circle: *d.*
III. 1. *a.* soil *b.* two dishes *c.* gelatin
    2. *a.* Sterilize a glass dish.
       b. Put sterile gelatin into the dish.
       c. Place grains of soil on the gelatin.
       d. Cover the glass dish and put it in a warm, moist place.

p. 47—*Bacteria in the Soil* (continued)

IV. Individual answers.
V. 1. The gelatin and the soil are still in the dish.
   2. Bacteria colonies can be seen after the gelatin and soil has been in a dark place.
VI. Place the soil in an environment which promotes the growth of bacteria.
VII. 1. yes
     2. yes
VIII. experimental proof

p. 48—*What Is in Soil?*

1–3. Individual answers.

p. 49—*Make a Map*

1. Check: *d*, *h*, *i*, *k*.
2. Circle: in *d*—Missouri, Mississippi Rivers, Wyoming, Gulf of Mexico.
   in *h*—Mississippi Valley
   in *i*—northern part
   in *k*—American Southwest
3. Obvious. Individual answers.
4. Examples: the Hudson River, the Mississippi, and the Columbia.

p. 50—*Make a Map* (continued)

Obvious. See p. 49 of the Companion Book.

p. 51—*Osmosis*

A. Check 1, 2, 3, 4.

p. 52—*Osmosis* (continued)

A. Check: 5 through 20.
B. 1, 3, 4. See pp. 127–128 of How and Why Conclusions.
   2. Circle: 10 and 11 in A.

p. 53—*Osmosis* (continued)

C. See pp. 125–128 of How and Why Conclusions.
D. 1. carrot . . cells
   2. water . . sugar solution
   3. carrot . . roots
   4. sugar molecules . . solution
   5. membranes of the root hairs
   6. molecules . . motion . . plant solution

p. 54—*Osmosis* (continued)

D. 7. membrane
   8. water molecules
   9. sugar molecules

10. water molecules . . water molecules . . sugar solutions
11. carrot . . osmosis
12. water and sugar . . pressure . . roots . . carrot

E.

5	before	1.	14	before	7.
6,7	"	2.	15	"	8.
8	"	3.	15	"	9.
9	"	4.	16,17	"	10.
12	"	5.	18	"	11.
13	"	6.	19,20	"	12.

F. Check: 3, 6, 7.

p. 55—*Food Transportation in Trees*

A. Key: See Companion Book p. 53, C.

B.
1. tree . . cells
2. water . . soil solution
3. trunk . . roots
4. water molecules . . tubes

p. 56—*Food Transportation in Trees* (continued)

B.
5. membranes of the root hairs
6. molecules . . soil . . motion . . plant solution
7. membrane
8. water molecules
9. food molecules
10. food molecules . . water molecules . . soil solution
11. root hairs . . osmosis
12. water . . pressure . . roots . . stems and leaves.

C. The water has entered the root hairs of the plant and moved up the plant.

p. 57—*Water and Plants*

1–3. Individual answers.

p. 58–59—*Growing Plants without Soil*

5. Individual answers.

p. 60—*Root Growth of Plants*

1. *a.* The roots of one grew straight down; the roots of the other turned.
   b. Individual drawings.
   c. The direction of the root growth is toward the water.
2. *a.* Individual drawings.
   b. The direction of the root growth is toward the source of the water. The shape and size of the root system are partly determined by the water available.

p. 61—*Effects of Root Growth*

1. There is no change in the color of the litmus paper.
2. *a.* The blue litmus paper turns pink.
   b. The water has become an acid.
   c. The roots have given off acid.
3. Individual charts.
4. Individual experiments.

p. 62—*The Meat We Eat*

Beef:	1. muscle, back	7. heart	13. tongue
	2. muscle, back	8. abdomen	14. leg
	3. leg, muscle	9. liver	15. shoulder
	4. leg	10. abdomen	16. neck
	5. leg	11. chest	17. back
	6. kidney	12. chest	18, 19. back
Pork:	1. back	5. leg	9. muscle
	2. shoulder	6. chest	10. leg
	3. head	7. abdomen	11. leg
	4. shoulder	8. abdomen	

p. 63—*The Habitats of Living Things*

	Similar	*Different*
Food	It is present.	It is growing in the air and from the soil.
Water	It is present.	It is the habitat of one. In the other it is part of the habitat.

Carbon Dioxide	It is present. It is used by plants for food making and exhaled by animals.	It is in the air in one and in the water in the other.
Protection	It is possible for the animals to be protected.	There is natural protection in one and protection by man in the other.
Place for the Young	It is present.	In one, places for the young are in or near the water; in the other, on the land.

Three water habitats: Individual answers.
Three land habitats: Individual answers.

p. 64—*Causes of Things*

A. 1. eggs
2. shell
3. basket . . tongs
4. seed
5. clean . . objects
6. starfish . . snails
7. industries
8. refrigerator cars . . airplanes . . canning . . freezing

B. Individual charts.

p. 65—*The Pineapple Plant*

1–2. See pp. 137–138 of How and Why Conclusions.

How Do Insects Affect Pineapple Plants?

Arrows from mealy bug to plant and from ant to mealy bug.
Mealy bugs were never found on dead plants, but only on healthy ones. Scientists did not know that after the mealy bug had killed the plant, ants moved it to a new plant.

p. 66—*Raising Wheat*

1. Check: *a*, *h*.
2. Some examples are:
   1. In 1840 one horse and a plow were used to prepare the ground; today gang plows drawn by tractors are used.

2. In 1840 branches were dragged over the ground to break up lumps; now a harrow is used.
3. In 1840 the seeds were planted by hand, but today power-drill seeders, which drop and cover the seed, are used.
4. In 1840 reaping, cutting, and binding were done by hand; now they are done by one machine, a binder.
5. In 1840 harvesting was done by hand, but today it is done by a threshing machine.
6. A new machine, the combine, now does the work of the binder and threshing machine.

p. 67—*How Flour Is Made*

Following arrows: Wheat . . sieves . . dust . . Cockle . . water . . Wheat . . grain . . bran . . purified . . Flour . . bags.

p. 68—*How Bread Is Made*

An example is:

1. Measure or weigh the ingredients.
2. In a mixing machine combine the sugar, shortening, salt, and water.
3. Add the correct amount of yeast dissolved in water.
4. Stir in some flour.
5. Beat the mixture until it is lighter.
6. Add more flour to make a stiff dough.
7. Knead the dough thoroughly to make it elastic.
8. Set the dough to rise in a warm place.
9. After the first rising, knead the dough again.
10. Divide the dough into loaves.
11. Let the dough in the loaves rise again.
12. Place the loaves in the oven to bake.
13. When baked, put the loaves in a machine that slices and wraps them.

p. 69—*Influenza*

1. Write 3 before *a;* 7 before *b;* 2 before *c;* 6 before *d;* 1 before *e;* 4 before *f;* 5 before *g.*
2. Individual graphs.

p. 70—*Effects of Diseases on the Human Body*

See p. 160 of How and Why Conclusions. Individual keys.

p. 71—*How Diseases Are Spread*

Picture 1: tuberculosis, influenza
Picture 2: tuberculosis, influenza
Picture 3: penumonia, influenza
Picture 4: tuberculosis
Picture 5: tuberculosis
Picture 6: encephalitis, poliomyelitis
Picture 7: typhoid fever
Picture 8: whooping cough

p. 72—*Causes of Diseases*

1. Micro-organism: tuberculosis, pneumonia, influenza, encephalitis, poliomyelitis, typhoid fever, whooping cough.
   Bacillus: tuberculosis, typhoid fever.
   Virus: influenza, encephalitis, poliomyelitis, whooping cough.
   Pneumococcus: pneumonia.
2. *a.* micro-organisms.
   b. bacillus . . virus . . pneumococcus
   c. different
   d. two . . typhoid fever
   e. different
   f. encephalitis . . poliomyelitis
   g. pneumonia (or tuberculosis)
   h. poliomyelitis
   i. tuberculosis . . pneumonia . . influenza
   j. encephalitis

p. 73—*Reading a Graph for Information*

1. *a.* Death Rate per 100,000 Population Due to Tuberculosis, Typhoid Fever and Diphtheria in One City from 1910 to 1940
   b. (1) death rates of different years

(2) death rate of tuberculosis compared to typhoid fever and diphtheria

(3) death rate of typhoid fever compared to tuberculosis and diphtheria

(4) death rate of diphtheria compared to tuberculosis and typhoid fever

2. Circle: *a, c, d, e, f.*
3. Check: *a.*
   Place an X before: *c, d, e, f.*
4. The number of deaths decreased.

p. 74—*Reading a Graph for Information* (continued)

5. *c*, 40 per 100,000; *d*, 60 per 100,000; *e*, less than 1 per 100,000; *f*, Most cases of typhoid fever, ⅓ less of tuberculosis; and very few cases of diphtheria (or any answer which makes a correct comparison).
6. Write 9 before *a;* 6 before *b;* 7 before *c;* 2 before *d;* 1 before *e;* 8 before *f;* 10 before *g;* 4 before *h;* 5 before *i;* 3 before *j.*

A Decrease in the Death Rate

Toxin antitoxin has been developed for diphtheria. People were immunized for diphtheria. Vaccine has been developed for typhoid fever. People were immunized for typhoid fever. People have learned how to prevent the spread of tuberculosis.

p. 75—*How Epidemics May Be Avoided*

1. State Sanitation Department: ordered chlorine poured into pipes.
   City Department of Health: set up a vaccination clinic.
   Telephone Company: warned people to boil water.
   Service Company: offered pure water.
   State Department of Health: sent vaccine to the city.

2. *a.* micro-organisms.
   b. micro-organisms.
   c. telephone
   d. boiling.
   e. purified.
   f. disease.
3. Scientific knowledge has been used to prevent an epidemic by purifying water, communicating with people, immunizing people, and killing micro-organisms.
4. Individual answers.

p. 76—*Two Kinds of Maps*

1. Hawaii; means of transportation; route to the United States from Hawaii; cities; physical features.
2. Individual states of the United States; months; the states in which the epidemic was each month.
3. Path epidemic traveled; the United States.
4. There are no symbols that need to be explained.
5. The Route of an Influenza Epidemic
6. The Route of an Influenza Epidemic

Obtaining Information From a Map

1. *a.* No, not from this map.
   b. west and southwest.
   c. The map shows these areas were affected in December, the earliest month mentioned on the map.
   d. north central and most of the northeast
   e. the southeast and parts of New England

p. 77—*Obtaining Information From a Map* (continued)

2–3. Individual routes.

p. 78—*How Can a Message Be Sent through Space?*

A. 173–1	180, 181– 8	185–15
175–2	173, 182– 9	186–16
175–3	182–10	186, 187–17
177–4	182–11	187–18
178–5	182–12	187, 188–19
178–6	182–13	188–20
178–7	183–14	189–21
		173–22

p. 79—*How Can a Message Be Sent through Space?* (continued)

B. Obvious.

C. Sound waves affect carbon grains through which a current flows. This current can be conducted to receiving sets and can cause sound waves to vary to the same degree that sound waves caused the electric current to vary in the transmitter.

p. 80—*The Action of Light Waves*

1. Individual drawings.
2. The light is reflected from the globe to the mirror and back to the globe again just as the radio waves are reflected back to the earth by the ionized layer of the atmosphere.
3. Radio waves and light waves are not the same kind of waves. Ionized layers change, but the mirror remains the same. Radio waves can go through many things that light waves will not go through. Radio waves can go much farther from the surface of the earth than can the light waves which came from a candle.

p. 81—*A Radio Condenser*

1. The more water in the bottle, the higher the pitch is.
2. Individual answer.
3. It vibrates only when the frequency of the waves in the bottle is the same as that of the waves of the tuning fork.

Early Experiments with Vacuum Tubes

1. negative
2. Streams of light would move away.
3. It must be made of particles.
4. Copper moved from the positive terminal to the negative.
5. negative particles of electricity
6. from the filament

p. 82—*Bones and Posture*

1. Obvious. See pp. 191–197 of HOW AND WHY CONCLUSIONS.

p. 83—*Bones and Posture* (continued)

2. *a.* Good posture: second picture in first column and first picture in second column.
   b. Obvious.
   c. Individual answers.
3. Individual answers.
4. It is difficult to keep the center of gravity of the body in line with the center of the earth because the body is pulled forward by the weight of the organs.

p. 84—*Bones and Posture* (continued)

5. Lines: Obvious.
   Mark X on 4.
6. center of gravity

p. 85—*Science Vocabulary*

1. endosperm: The inner part of the kernel which contains the starch and the protein.
2. influenza: A disease caused by a virus.
3. vaccine: A solution made with the dead micro-organisms which cause the disease.
4. antibodies: Materials produced by the body when a vaccine is injected into the body.
5. immunity: Condition of the body that makes it possible to resist disease.
6. distemper: A disease.
7. encephalitis: Sleeping sickness (some believe it to be a virus disease).
8. radio transmitter: The sending part of a radio system.
9. radio receiver: The receiving part of a radio system.
10. microphone: The device in the radio transmitter which uses sound waves to cause an electric current to vary.
11. static: Electrical disturbances heard in the radio.
12. frequency: Number of waves sent out per second from broadcasting station.
13. vacuum tube: The most important part of the transmitter.

14. filament: The part of the vacuum tube which is positively charged.
15. plate: The part of the vacuum tube which attracts the electrons.
16. grid: The part of the vacuum tube which is negatively charged.
17. skull: The bones which form the head.
18. pelvic bones: A group of large, flat bones where the vertebral column ends and the legs begin.
19. skeleton: The bones of the body.
20. naris: One of the openings at the end of the nose.

p. 86—*Different Kinds of Milk*

A. Individual answers.
B. Individual answers.

p. 87—*The History of Soil in the United States*

Picture 1: *a.* Example: Michigan.
b. It is being carried away by the river; it is being held by the forest.
c. trees; grass
d. nothing
e. Trees and Grass Hold the Soil

Picture 2: *a.* The Great Plains
b. The short grass held the soil in place; when the grass was gone the soil blew away.
c. plants, animals
d. nothing—the short grass should be undisturbed
e. Individual answers.

p. 88—Picture 3: *a.* The Rocky Mountains
b. It is being carried away by river, glacier, wind, rain. It is being formed.
c. trees
d. nothing
e. Individual answers.

Picture 4: *a.* Southwest—desert.

b. It is being transported by wind. It is being formed.

c. plants

d. water, cover crops (native grasses)

e. Individual answers.

p. 89—*What Happened to a Tree?*

1. obvious.
2. 10 years
3. 9 years
4. There is thicker, wider space between the rings.
5. The fire scars are at the top of the diagram.
6. disease organisms, insects
7. not putting out a campfire; not putting out a cigarette; lightning

p. 90—*Erosion in your Community*

1. Individual maps.

p. 91—*Erosion in your Community* (continued)

2–3. Individual answers.

4. *a.* It had been carried by the river which had eroded the land.

   b. The river had transported it to other places. Nothing had been done to hold the soil.

p. 92—*How Can We Keep the Soil?*

1. Soil is conserved in #1 and stays on the land. In #2 water is eroding soil from lack of plants to hold soil.
2. They have planted trees and other plants.
   They have made a lawn.
   They have filled in any gulleys which may have existed.
   They have controlled the course of the stream.
3. Gulleys may be filled in by grading or by placing small dams across the gulleys to hold the water back. Grass can be planted as in contour farming to help hold the soil, or the hill may be terraced.

p. 93—*Irrigation*

1. *a.* Water is being used for irrigation.
   b. #1—Water is in ditches. #2—Water is on land and surrounded by a border of soil to keep it in. #3—Land is terraced and plots surrounded by soil to keep water in.
2. Obvious.
3. *a.* The amount of water put on the land can be controlled. Water can be carried for long distances. Machinery is used to control the flow of water.
   b. Irrigation must be planned so that the flow of water is from a higher to a lower place. Fields must be ditched in accord with the above fact.

p. 94—*Irrigation* (continued)

Key: Color areas with a precipitation of 24 inches or less.

p. 95—*A Conservation Map*

A–B. Individual maps.

C. 1. Strip cropping: Alternate strips of cover crops and crops to be harvested are planted parallel to the contour lines.
   2. Roadside improvement: Grass and shrubs planted on the shoulders. Drainage systems installed to prevent gully formation.
   3. Flood control: Rivers and streams dammed to control courses and to eliminate flood plains; forests and cover crops planted to hold soil.
   4. Terracing: In terracing, the slope on top of each terrace can be cut down to the point where erosion is not so likely to occur.
   5. Stream bank improvement: Constant repair and planting of plants to prevent banks being eroded.
   6. Check dams: Small dams on small streams which slow down flow of water and prevent soil from being carried away.

p. 96—*A Conservation Map* (continued)

C. 7. Wind break: A row of trees to break the wind and prevent soil from being blown away.

8. Listing: A way of plowing furrows which leaves soil on each side.

9. Gully control: Grading of gully or small dams will help hold water back and prevent erosion of sides of gully or deepening the gully.

10. Terrace outlet: An opening in the ridge around a terrace which is usually cemented and used to carry off excess water.

11. Grazing: Land used for this purpose is not plowed, therefore a cover is maintained which helps keep the soil.

12. Run-off control: Anything which helps keep the water on the land—proper drainage, canals, use of water while on land.

13. Log dams: These slow up water so that erosion of soil is not so rapid; they also help hold the soil behind them.

14. Reforestation: Additional trees help hold water in the soil and help hold the soil in place.

p. 97—*Reclamation of Land*

Individual titles.

#1 shows a hilly country covered with trees and shrubs, streams flowing into valleys to a large river.

#2 shows this country populated—farms, village.

#3 shows a community built where the farms and village were, but barren front yards, few trees, rocky places.

#4 shows trucks hauling dirt from the river to the houses, spreading dirt on the lots.

#5 shows well tended lawns and flowers, new trees and shrubs growing.

p. 98—*Science Vocabulary*

1. lactic acid: The acid that accounts for the taste of sour milk.

2. whole milk: Milk as it comes from the cow.
3. pasteurization: Milk which is not heated to boiling point, but hot enough so micro-organisms are killed.
4. rennet: A substance secreted by stomachs of mammals.
5. whey: The liquid part of curdled milk.
6. desert: A vast expanse of dry, rather barren land.
7. erosion: The carrying away of soil by water or wind.
8. irrigation: The process of applying water to the land through canals or ditches.
9. sheet erosion: The removal of an even layer of soil particles from a piece of land.
10. furrow erosion: The formation of small, irregular, winding paths in the surface of the soil.
11. gully erosion: Deep clefts in the soil caused by rapid and uncontrolled erosion.
12. rotation: A succession of different crops on each field.
13. water table: The level at which water stands in the soil.
14. headgates: Gates which regulate the amount of water that flows from irrigation canals.
15. laterals: Smaller ditches to different fields or to parts of fields.
16. furrow irrigation: Furrows made between the rows of growing crops. Water allowed to flow through the furrows.
17. flooding: Water allowed to flow out over the land.
18. border irrigation: Plots of land with border of soil around them are flooded with water.
19. dry-land farming: A method of raising crops in dry areas where there is little rainfall and no supply of water for irrigation.
20. fallowing: Practice of letting the land lie idle to store up moisture.

p. 99—*What Makes the Engine Run?*

1. *a.* air (oxygen, nitrogen, carbon dioxide), gasoline
   b. water, carbon dioxide
   c. See pp. 248–258 of How and Why Conclusions.

2. *a.* combustion . . carbon dioxide
   b. oxygen . . carbon dioxide . . water
   c. air . . vapor
   d. oxygen . . carbon dioxide
   e. oxygen . . water

p. 100—*The Four Strokes of the Engine*

Clockwise from upper right quarter of circle:

1. Gasoline vapor burned.
   Gas expansion moves piston.
   Crank turns and turns flywheel.
2. Turning flywheel causes piston to move toward head of cylinder.
   Exhaust valve opens.
   Burned gases are pushed out.
   Exhaust valve closes.
3. Flywheel moves piston down.
   Gases expand.
   Intake valve opens.
   Gas vapor and air move into cylinder.
4. Piston starts up.
   Intake valve closes.
   Exhaust valve closed.
   Gases compressed.
   Spark occurs.

p. 101—*Internal and External Combustion Engines*

1. See pp. 249–253 of How and Why Conclusions.
2. Obvious.

p. 102—*Internal and External Combustion Engines* (continued)

3. *a.* In the external combustion engine the fuel can burn almost anywhere as long as it turns water into steam which can be led into the cylinder. In the internal combustion machine the fuel is burned in the cylinder.
   b. A water tank, a method of burning the fuel, a method of conducting the steam to the cylinders.
   c. Individual drawings.

p. 103—*Temperature and Pressure*

2. *a.* *b.* *c.* Individual answers.
3. *a.* It rises.
   b. Heat (The can becomes hot which heats the air in the can.)
   c. Air in the can expands and fills the balloon.
   d. Expanding gases in the cylinder force the pistons downward.

p. 104—*Temperature and Pressure* (continued)

4. Individual drawings and answers.

p. 105—*How the Cylinders Work*

See pp. 249–257 of How and Why Conclusions.

p. 106—*How Is the Spark Produced?*

1–3. See pp. 249–257 of How and Why Conclusions.
4. When the spark plug is screwed into the cylinder, the points project a little into the cylinder.

p. 107—*Changing Speeds*

1. *a.* The throttle valve is turned.
   b. There is a wider opening for gas to enter cylinders.
   c. More mixture of fuel and air can enter cylinders.
   d. More mixture causes more powerful strokes and the engine runs faster.
2. *a.* The throttle valve is turned.
   b. There is a smaller opening for gas to enter cylinder.
   c. Less mixture of fuel and air can enter cylinder.
   d. Less mixture, less powerful strokes, and engine runs slowly.
3. There is a screw on throttle lever which holds throttle open far enough to keep engine running slowly.

p. 108—*Getting Started*

1. Push the starter pedal.
2. Starter gear is connected with flywheel gear.
3. Switch is closed.

4. Current is sent from battery to starting motor.
5. Current starts the starting motor.
6. Motor sets starter gear in motion.
7. Starter gear sets flywheel gear in motion.
8. Flywheel moves crankshaft of engine.

p. 109—*The Driver and the Car*

1. Individual answers.
2. Obvious.

p. 110—*Drivers in your Community*

1–4. Individual answers.

p. 111—*My Weight*

Individual answers.

p. 112—*My Immunization Record*

Individual answers.

My Clothing

1. (1) Circle: *a* through *h*.
   (2) Check: none.
2. They protect the body from changing temperatures, drafts, the cold, and moisture, all of which lower resistance to disease.

p. 113—*My Teeth*

1–3. Individual answers.

My Sleep and Rest

A. Individual graphs.

p. 114—*My Sleep and Rest* (continued)

B. 1–14. Individual answers.
   15. Circle: 4, 6, 7, 8, 10, 11. They are practices which insure adequate rest in a well-ventilated room.

C. 1. Individual answers.
2. Not getting enough sleep or restful sleep.

p. 115—*My Hearing and Seeing*

Individual answers.

My Work and Play

Individual answers.

p. 116–117—*My Health Autobiography*

Individual answers.

p. 118—*Fish, Turtles, and Crabs*

(It may be necessary for the teacher to give the common name in each case.)

First Column:

Porkfish	Anisotremus virginicus
Blue Angelfish	Angelichthys ciliaris
Blue Parrotfish (done)	Scarus caeruleus (done)
Queen Triggerfish	Balistes vetula
Moorish Idol	Zanclus cornutus

Second column:

Sargassumfish	Histrio pictus
Cowfish	Acanthostracion quadricornis
Yellow-Finned Grouper	Trisotropis venenosus
Surgeonfish	Acanthurus hepatus
Lionfish	Pterois volitans

p. 120—*Fish, Turtles, and Crabs* (continued)

First column:

Common Sea Horse	Hippocampus hudsonius
Common Saw Fish	Pristis pectinatus
Guitar Fish	Rhinobatos productus
Sand Shark	Odontaspis littoralis
Sting-Ray	Dasyatis hastatus

Second column:

Scorpionfish	Scorpaena plumieri
Nurse Shark	Ginglymostoma cirratum
Smooth Dogfish	Cynias canis
Winter Skate	Raja diaphanes
Butterfly Ray	Pteroplatea micrura

p. 121—*Fish, Turtles, and Crabs* (continued)

Fish: Covered with scales.
Body divided into head, trunk, and tail.
Fins on sides, back, and bottom.
Mouth; gill covers.
Eyes on each side of head.
Internal skeleton.

Sharks: Paired fins.
Lower jaw.
Mouth a slit on bottom (ventral) part of head.
Eyes on each side of head.
Internal skeleton.

Skates and Rays: Very flattened.
Long tails (except one).
Mouth on bottom (ventral).
Eyes on top.
Wing-like structure extending from central part of body.
Internal skeleton.

Turtles: Shell broad and flattened.
Head, tail, legs projected from shell.
Internal organs protected.
Eyes on each side of head.
No teeth. Four legs
Head flat, triangular.
Internal skeleton.

Shrimps, Crabs, Lobsters, and Crawfish:
External skeleton.
Different numbers of legs.
Possess claws of some kind.
Part of body segmented.

Covered with shell.
Eyes on each side of head.
Most of them have tails.

p. 122—*Fish, Turtles, and Crabs* (continued)

First column:

Mangrove Crab	Goniopsis crumentata
Crawfish	Cambarus bartoni
Common Lobster	Homarus americanus
Spiny Lobster	Panulirus argus
Horseshoe Crab	Limulus polyphemus
Salt Water Shrimp	Penoeus seliferus

Second column:

Brier Skate	Raja eglanteria
Slider	Chrysemys elegans
Florida Cooter	Chrysemys floridana
Diamond-Back Terrapin	Malacoclemmys palustris
Alligator Snapping Turtle	Macrochelys lacertina
Soft-Shell Turtle	Trionyx spinifer

p. 123—*Fish, Turtles, and Crabs* (continued)

3. Organs of locomotion.
   Covering of body.
   Shape of body.
   Placement of eyes, mouth.
   Kind of tail. Body divisions.
4. Individual answers.
5. Obvious.

p. 124—*Fish, Turtles, and Crabs* (continued)

6. Individual drawings.

p. 125—*An Egg Collection*

1–3. Individual answers.

p. 126—*Egg Shells*

Individual charts.

1. To protect the embryo from other animals, bacteria, etc. To protect the egg from dehydration when left in the air.
2. With shell: More care given eggs.
   Fewer eggs laid.
   Land animals lay them.
   Most of the animals have feathers.
   They are more complex animals.

   Without shell: Less care given eggs.
   More eggs laid.
   Laid by water animals.
   Most of the animals do not have feathers.
   They are simpler animals.
3. The vinegar caused the egg to change so that it was no longer hard. Some substance in the egg must have been changed by the vinegar.

p. 127—*Some Questions About Chicken Eggs*

1. They have been candled.
2. If yolk stands high and firm it is fresh egg and good to eat.
3. The shell is translucent.
4. It is a little red dot in the yolk.
5. So the germ spots do not get any bigger.
6. The eggs have been fertilized.
7. They do not need to be fed for a day or two after they are hatched.
8. They contain no germ spots.
9. The embryo.
10. A fertilized egg which has started to develop and died; bacteria.
11. One in which changes have taken place in air in egg.
12. Changes in air in egg; odors carried in air which enters egg.
13. By the appearance of the yolk.
14. The food of the chicken influences the color of yolk.

p. 128—*How Many Produce Eggs?*

1. amoeba

2. virus
3. bacteria
4. wheat grain
5. oyster
6. tadpole
7. frog
8. man
9. cow
10. chicken

Draw eggs above: 5, 7, 10.

p. 129—*Science Vocabulary*

1. cylinder: The place where the fuel burns.
2. mixer: A tube through which air passes.
3. carburetor: The place in which gasoline and air are mixed.
4. connecting rod: The bar which connects the piston with the crank.
5. flywheel: A heavy wheel attached to the crank.
6. points: The end of the rod and the end of the small curved metal projection in the spark plug.
7. voltage: Pressure.
8. amperage: Quantity of electricity.
9. water jacket: Spaces around each cylinder and each valve.
10. clutch: A device which makes it possible to connect engine to driving parts and disconnect engine from driving parts.
11. transmission: Gear box, case, and the gears and other parts.
12. differential: A set of gears which attaches ring gear to axles.
13. translucent: Some light can go through.
14. sperm cells: Cells in rooster which unite with egg cells of the hen.
15. egg cells: Cells in hen which unite with sperm cells of rooster.
16. fertile eggs: Eggs which have been fertilized.

17. air cell: Small, lighter-colored area at large end of egg.
18. ovary: Tissue in hen which enlarges and produces egg cells.
19. candling: A method of testing eggs to determine if they are good to eat.
20. molt: Shedding of feathers each year.

p. 130—*The Heart and the Blood*

1–2. Individual answers.

p. 131—*The Heart and the Blood* (continued)

3–4. Individual answers.

p. 132—*The Heart and the Blood* (continued)

5. Individual answers.

The Pulse Rates of Some Animals

1–3. Individual answers.

pp. 133–134—*The Activity of the Heart*

Individual answers.

p. 135—*Water and Heat*

Individual drawings.

The colored water flows up into the uncolored water because the blue water is hotter and lighter which causes it to move upward as the colder, heavier water pushes downward and forces it up.

pp. 136–137—*Questions about Our Water Supply*

See pp. 359–364 of How and Why Conclusions

p. 138—*Making a Place for Micro-organisms to Grow*

1. To kill any micro-organisms which might be on the potato.
2. To kill any micro-organisms that might be on the wire.
3. Micro-organisms are so small that one drop of water may contain all the micro-organisms needed.
4. So that the micro-organisms from the air will not enter.

5. To know if the micro-organisms came from the water or would have developed without the water being there.

p. 139—*How Pure Is Water?*

1–2. Individual answers.
3. Results will vary, but conclusions should be that the water which has been boiled has no micro-organisms in it which develop on the potato. Hardness or softness does not make any difference in the presence of micro-organisms.

p. 140—*Precipitation in Water*

1. *a.* It collects in large pieces and sinks.
   b. Individual drawings.
   c. The alum causes the small particles of the scum or sand to cling together in larger pieces. The larger pieces sink because of the pull of gravity.
2. The sewage may enter in small particles which would be difficult to handle unless something was added to the water to make them cling together and sink to the bottom of the tanks. From there the sludge can be conducted to the parts of the plant which would make the sludge harmless in river water.

p. 141—*The Softness of Water*

1. Individual answers.
2. Those kinds of water that are soft have little or no mineral compounds in them.

p. 142—*Effects of Temperature Changes*

1. Rising warm air pushes up the ascending spiral; descending cold air pushes the spiral down.
2. Air currents are caused by the unequal heating of the air.

p. 143—*Wind Direction*

Individual maps.

p. 144—*What Makes an Airplane Fly?*

1. air
2. air
3. shape
4. airfoil
5. force
6. motion
7. line
8. pressure
9. wing . . reduced
10. lift
11. still
12. move
13. the lift
14. the lift
15. changes
16. warm air
17. opposite directions
18. air
19. thrust
20. blades
21. airfoil
22. thrust
23. air itself
24. retractible
25. cowling

p. 145—*What Makes An Airplane Fly?* (continued)

26. friction at such points as the joining between the wings and the fuselage, or the body of an airplane
27. airplane

How to Make an Airfoil

Individual drawings.

Air Presses

1. No. The air pressure on the water in the pail keeps the water in the can.
2. Yes. Air rushes in through the holes and air pressure pushes the water out.

p. 146—*Materials in Airplanes*

1. Asbestos—South Africa
   Mercury—California
   Cobalt—Canada
   Nickel—Canada
   Manganese—Montana

Cadmium—Canada
Iron—Wisconsin
Lead—Missouri
Mica—North Carolina
Cotton—Texas
Asbestos—Arizona
Tungsten—China, Australia
Chromium—Philippine Islands
Tin—Bolivia
Platinum—Colombia

p. 147—*Materials in Airplanes* (continued)

2. See the answer for exercise 1, p. 146.

p. 148—*Balancing a Plane*

1. Individual answers.
2. Individual drawings.

p. 149—*Parts of an Airplane*

1. stabilizer: to hold up the tail during flight; helps to balance the airplane
   elevator: changes the direction of the airplane for a climb or a descent
   rudder: to steer airplane, change direction of flight
   ailerons: raise and lower the ends of the wings
   stick: controls or moves the rudder and ailerons
   tabs: counteract the effect of too much weight on one side or at the end.
2. See pp. 380–385 of How and Why Conclusions.

p. 150—*Making an Aneroid Barometer*

1. Changes in air pressure on the rubber (diaphragm) across the top of milk bottle.
2. Individual charts.

p. 151—*Airplane Instruments*

1. Shows the speed of the airplane compared to the speed of the air through which it is travelling; connected to a

pitot tube projecting from the wing or fuselage; the pressure in the tube is proportional to the speed of the airplane against the relative wind.

2. Shows the direction of travel; has a magnetized steel needle which points toward the north magnetic pole of the earth; this needle is attached to a disc having letters, representing North and West, South and East.
3. Shows the altitude of the airplane; it registers height by variation in air pressure; as the air becomes lighter, this is registered on the altimeter as distance above sea level.
4. Shows the airplane's horizontal position; a line representing the horizon appears behind the glass of the instrument; the line is drawn on a sphere held by gyroscopes so it is always in the same position; thus, the pilot can always see whether the airplane is flying level, climbing, or descending.

p. 152—*Types of Airplanes*

Airplanes	*Characteristics*
I. Wing Design	
A. Biplanes	Two wings
1. Staggered wings	Wing ahead or behind each other
a. Positive stagger	Upper wing ahead
b. Negative stagger	Lower wing ahead
B. Monoplanes	One wing
1. Low-wing monoplane	Wing low, attached near bottom of fuselage
2. Medium-wing monoplane	Wing attached near middle of fuselage
3. High-wing monoplane	Wing attached near top of fuselage
4. Parasol monoplane	Wing extends above fuselage
II. Use	
A. Commercial	Used by business companies
B. Military	Used by military
C. Private	Used by individuals

III. Place	
A. Land	Take off, alight, and fly over land
1. Transport	Transport goods
2. Army	Owned by Army
3. Private	Owned by individual
B. Water	Take off, alight, and fly over water
1. Seaplanes	Floats instead of wheels, wing floats
2. Flying boats	Fuselage shaped like hull of boat, wing floats
3. Amphibious	Alight on land or water, wing floats
IV. Lift produced by rotors	
A. Helicopter	Wing rotates to produce lift, engine moves rotor
B. Autogiro	Air action moves rotor

pp. 153–154–155—*The Uses of Airplanes*

Individual answers.

p. 156—*Science Vocabulary*

1. carbonic acid: A substance in the blood, produced when carbon dioxide dissolves in water.
2. auricles: The cavities which hold the blood before it enters other parts of the heart.
3. pulmonary system: The part of the blood system which flows through the lungs.
4. apex: The bottom of the heart.
5. lymph: Liquid of the blood which has moved from the blood into the spaces between the cells of the body.
6. hemoglobin: A pigment in the red corpuscles with which oxygen combines.
7. abscess: A big collection of pus at any point in the body.

8. impurity in water: Any undesirable substance mixed with water.
9. purification: Process of removing impurities from water.
10. chlorine: A chemical used to treat water.
11. soft water: Water which does not have many dissolved mineral compounds.
12. hard water: Water which has many dissolved mineral compounds.
13. airfoil: The upper surface of wing is curved, the lower surface of wing is flat. This shape known as airfoil.
14. lift: Difference in pressure which holds airplane up.
15. thrust: The higher pressure on the back, flat side, exerts a forward pressure called thrust.
16. drag: A force which pulls against thrust.
17. fuselage: Body of airplane.
18. altimeter: Instrument used to determine altitude of airplane.
19. robot: A machine having the ability to do the work of human beings.
20. Mount Everest: The highest mountain in the world; in Himalayas.

pp. 157–158—*A New Method of Transportation*

Individual answers.

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